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FIFTY-SECOND ANNUAL REPORT

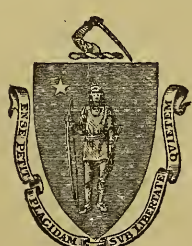
OF THE

MASSACHUSETTS AGRICULTURAL COLLEGE.

PART I.

REPORT OF THE PRESIDENT AND OTHER OFFICERS OF ADMINISTRATION

FOR FISCAL YEAR ENDED NOV. 30, 1914.



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Approved by
The State Board of Publication.

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The Commonwealth of Massachusetts.

MASSACHUSETTS AGRICULTURAL COLLEGE,
AMHERST, Dec. 1, 1914.

To His Excellency DAVID I. WALSH.

SIR: — On behalf of the trustees of the Massachusetts Agricultural College I have the honor to transmit herewith, to Your Excellency and the Honorable Council, Part I. of the fifty-second annual report of the trustees, for the fiscal year ended Nov. 30, 1914, this being the report of the president of the college and other officers of administration to the corporation.

I am, very respectfully, your obedient servant,

KENYON L. BUTTERFIELD,
President.

REPORT OF THE PRESIDENT OF THE COLLEGE.

Gentlemen of the Corporation.

I herewith submit my annual report as president of the Massachusetts Agricultural College.

First of all, I wish to convey my hearty personal thanks to you as trustees for your generous action in allowing me a year's leave of absence which ended last May. For considerably over one-half of the period my services were given to the United States and American Commissions on Agricultural Credits, traveling with the commissions in Europe and assisting in the preparation of reports. The entire year was a fruitful one in the widening of observation, the enlarging of acquaintance, and the opportunity for study in fields fundamental to the development of large rural policies.

During my absence Prof. Edward M. Lewis served as acting president, not only with energy and efficiency, but with great acceptability to students, faculty and, I am quite sure, to your Board of Trustees. The position of acting president is never a sinecure, but Dean Lewis met every requirement with sympathy, skill, and thoroughgoing loyalty to the policies of the institution.

GENERAL REVIEW OF THE YEAR.

Dean Mills.

The death of Prof. George Franklin Mills on Oct. 27, 1914, has taken from us an able member of our staff and a man whose long service, high character, and genuine friendliness had endeared him to all with whom he came in contact. Dean Mills had served the college for nearly twenty-five years, having joined the faculty early in January, 1890. For a large part of his career he was a teacher of English; for many years he was the faithful and hard-working treasurer of the institution; for seven years he was dean of the college. Last June he was made dean emeritus.

Perhaps the best tribute that can be offered, in this report, to the work and life of Dean Mills is to quote the resolutions passed by your Board of Trustees on Nov. 6, 1914: —

Whereas, The Board of Trustees of the Massachusetts Agricultural College is saddened by the death of its late dean, Prof. George F. Mills, and desires to give enduring expression to its appreciation of his high character and faithful services as an officer and instructor in the college;

Resolved, That by his death the college loses an invaluable officer who for twenty-four consecutive years has, with rare intelligence, fidelity, and unfailing courtesy, facilitated the success of the college, and the community loses a true gentleman and an exemplary citizen;

Resolved, That the trustees of the college commend the example presented by his long and honorable career to all who aspire to render unselfish and devoted service in educational work;

Resolved, That a copy of these resolutions be transmitted to the family of the late dean, to whom this Board extends its profound sympathy in their bereavement, and that a copy be placed on the records of the Board.

May I also add a personal word. I came to know Dean Mills quite intimately and felt his influence constantly, — indeed it is a perpetual possession. His loyalty to what he believed to be right, his conscientious performance of duty, his genuine interest in men, his chivalric attitude in all human relationships, his fortitude in illness and suffering were both a lesson and an inspiration. There is no greater tribute than to apply to him the old-fashioned phrase, "a Christian gentleman."

Mr. Georgia.

On May 24, 1914, Mr. Bert C. Georgia, the instructor in market gardening, died suddenly. Mr. Georgia had been with us only the year, coming from recent graduation at Cornell. His work was efficient, and his character and personality had already made a place for him in our ranks. His sad death at the threshold of what promised to be a fine career was a distinct shock and sorrow.

Major Anderson.

In the death of Maj. John Anderson, which occurred Aug. 27, 1914, at his home in Belchertown, Mass., this college lost a true and loyal friend. Major Anderson served as professor of mili-

tary science and tactics at this institution from January, 1900, until September, 1905, and thoroughly won the love and respect of the students who during that period were privileged to know him. He was born in Monson, Mass., enlisted in the army in 1863, and was in active service during the rest of the civil war. At the close of the war he joined the regular army as second lieutenant, and worked his way up through the grades to the rank of major.

Changes in Trustees.

Owing to an appointment on another board, Hon. Charles E. Ward of your Board of Trustees resigned in August, 1914. Mr. Ward had rendered unusually efficient and intelligent service during his membership on the Board; his broad spirit, keen mind, and wide experience gave his service distinction. His successor, Mr. Edmund Mortimer, is a man of large affairs, great energy, and genuine interest in the work for which we stand.

Resignation of Professor Eyerly.

Prof. E. K. Eyerly, on September 1, resigned as head of the Department of Rural Sociology, to accept an important administrative and teaching position in the University of South Dakota. Professor Eyerly was released for this service, and his work is being carried on by other members of the department. Professor Eyerly was probably the first man in this country to organize and develop a district department of rural sociology. During his incumbency the interest and enrollment in the subject materially increased, and the type of work for which the department stands has found its place in the institution and among the students.

New Professorial Appointments.

Early in the year the vacancy caused by the resignation, in July, 1913, of Prof. E. A. White as head of the Department of Floriculture was filled by the appointment of Prof. A. H. Nehrling, who came to us from the University of Illinois. Professor Nehrling was educated in Washington University and the Shaw School of Botany, St. Louis, has served as an instructor in school gardening in South Chicago public schools

for three years, and for two years as an instructor in floriculture at the University of Illinois. At the time of leaving Illinois he was associate in floriculture in both the University and experiment station. Professor Nehrling has taken hold of this important department with energy and skill.

Prof. R. H. Ferguson was appointed to the position of extension professor of agricultural economics. Professor Ferguson was educated in the Christ Church Normal School, Belfast, Ire., and in Canterbury College, New Zealand. He is also a graduate of the Ontario Agricultural College and has taught in the State of New York. He has been assistant director of agricultural education in the Province of Ontario, and was county agent in the State of Virginia just before coming to Amherst. Professor Ferguson's work is to assist in the problem of the marketing and exchange of agricultural products and supplies. He is at the disposal of groups of farmers desiring a presentation of the principles of business co-operation, and, in general, of the exchange side of agriculture.

Prof. C. I. Gunness in July accepted the associate professorship of rural engineering. Professor Gunness graduated from the mechanical engineering department of the North Dakota Agricultural College in 1907, served for two years as instructor in mechanical engineering in that institution, and for three years as assistant professor. For the two years prior to his engagement here he was superintendent of the Indiana School of Tractioneering. He is a member of the American Society of Agricultural Engineers.

Attendance.

The total attendance of students registered in work of college grade is only slightly in excess of the enrollment of a year ago. The registration in the four undergraduate classes has decreased by 16, while the number of graduate students has increased by 13, and the number of unclassified students by 8. The total enrollment this year is 610 as compared with 605 last year. There was a noticeable decrease in the number of students entering the freshman class; for the past five or six years we have had an annual increase of from 15 to 20 in our entering class, or of approximately 8 per cent. over the preceding year;

this autumn, however, the entering class numbered 168, a decrease of 33, or 16 per cent. over the class entering in 1913. Thirty-two men were admitted to the freshman class who did not report. An investigation has been made among these men to ascertain their reason for not entering, and while there is no uniformity with respect to the nature of the replies, it is evident that a large number were prevented from entering on account of financial difficulties. (See Table V. for analysis of the enrollment.)

Short Courses.

The usual winter and summer schools have been conducted during the past year with marked success. The registration in the ten weeks' winter course has in recent years increased constantly, so that in 1914 182 members were enrolled. The Farmers' Week was largely attended, the enrollment being between 1,500 and 1,700. The Summer School of Agriculture and Country Life was held in July, and had an attendance of 146. The Conference on Rural Community Planning, immediately following, enrolled 329. The boys' camps were this year even more successful than last. Although the weather was unfavorable at the time of the poultry convention in July, there was an attendance of over 600.

Commencement.

The annual Commencement Day exercises were held Wednesday, June 17. The number receiving the degree of Bachelor of Science was 98, this class being slightly larger than that of 1913. The degree of Master of Science was conferred on 8, and the degree of Doctor of Philosophy on 3. The latter two facts are indicative of the increased attendance at this institution of men desiring advanced training in agriculture, horticulture, and the sciences relating thereto. The alumni dinner was attended by 189 alumni and officers of the college. Prof. Bliss Perry of Harvard University delivered the Commencement address, his subject being "The College and the Commonwealth."

Change in Course of Study.

After an extended discussion of the curriculum of the first two years, the faculty in the spring of 1914 adopted and presented to the trustees a revision of the course of study for this period. The changes made involve a reduction in required work in a modern language from three to two semesters, a study of agriculture and horticulture throughout the freshman and sophomore years, and a more even distribution of difficult subjects now required in the sophomore year. The plan also contemplates offering several electives in both semesters of the sophomore year, whereas at present only a comparatively few electives are available, and these only in the second semester.

The trustees at a recent meeting passed a resolution that "the faculty be requested to make a study, and to prepare a report thereon, of the entire curriculum with reference to its full adaptability to the training of students for the various agricultural vocations, and also in citizenship and in general culture." This resolution opens the way for a thoroughgoing study of the entire college curriculum from the standpoint of the main purpose of the college.

Lectures on "World Politics."

In the fall of 1913 the trustees established a permanent lectureship in world politics. At the close of the last fiscal year the first series of lectures on this subject was being delivered by Mr. R. L. Bridgman of Boston. The lectures were well attended, and excellent interest was shown by students and faculty in the specific lectures given, as well as in the general subject involved. This autumn (Oct. 21, 1914) Dr. Edwin D. Mead of the World Peace Foundation visited the college and delivered two lectures. The topic of the first was, "The United States and the United World," and of the second, "War and Peace in 1914." Dr. Mead had just returned from Europe and the seat of war, and made a particularly strong appeal to his audiences here.

Visit of Dr. Sato.

In March Dr. Shosuke Sato, the exchange lecturer from Japan to the United States, delivered at the college three lectures on the industrial, economic, and educational conditions in Japan. Dr. Sato's visit to this institution was of particular interest because of the fact that he is president of the University of Sapporo, Japan, which was founded by Dr. William S. Clark, for twelve years president of the Massachusetts Agricultural College. Dr. Sato was a student under both Dr. Brooks and Mr. William Wheeler of the trustees. The students and faculty gave Dr. Sato a cordial welcome, and his lectures were well attended and highly appreciated.

Chinese Students' Conference.

The eastern section of the Chinese Students' Alliance of America held its tenth annual convention at this institution Aug. 28 to Sept. 4, 1914. This meeting was significant, in part, because in the summer of 1905 there was held at this institution the first formal gathering of the Chinese students of America. At that time about 30 Chinese students met here for several days and organized the "Chinese Students' Alliance." The growth in numbers and influence of this organization has been phenomenal, and to-day approximately 1,000 Chinese students in various parts of the United States are members of the organization. Conferences are held annually in the western, central, and eastern sections of the country. Over 100 were in regular attendance at the Amherst conference this year. A well-organized program was arranged for each day, embodying talks on vocations, literary programs, athletics and other forms of amusements, business meetings, and public entertainments. The officers of the alliance were very appreciative of the courtesies extended by the college, and at the close of the conference the following resolution was adopted and presented to the president: —

In recognition of the kindness and hospitality on the part of President Butterfield and the authorities of the Massachusetts Agricultural College, be it resolved that a vote of thanks be tendered to the same authorities.

Social Service Commission.

For three or four years there has been discussed among the students and faculty the desirability of securing a paid leader who should devote his time in developing, among the students, various lines of social service at the college, in Amherst, and in the surrounding towns. As a result of these discussions several men met in the spring of 1913 and organized what is known as the "Social Service Commission of the Massachusetts Agricultural College." The constitution adopted by this body follows: —

Article I.

Name. — The name of this commission shall be the Social Service Commission of the Massachusetts Agricultural College.

Article II.

Object. — The object of this commission shall be to use and train the students in social service, especially in rural social service in near-by communities, expecting —

First, the development in the students of leadership and Christian character.

Second, the use and co-operation of the various student and community organizations.

Article III.

Membership. — The commission shall consist of nine members, the president of the college, and eight annually appointed by him from faculty, students, alumni, and the community at large; not more than three shall be appointed from the community at large.

Article IV.

Officers. — The officers of this commission shall be a chairman and a clerk, both of whom shall be elected by ballot immediately after the appointment of the commission, and a treasurer, who shall be the treasurer of the college.

Article V.

Meetings and Duties. — This commission shall meet at least twice each year. It shall have full charge and responsibility for raising and disbursing money, the employment of a social service secretary, and the directing of his work. At its meeting in September it shall outline its program of work for the ensuing college year.

Article VI.

Amendments. — This constitution may be amended by two-thirds' vote of the commission, serving in any one year.

A canvass was made of the alumni for the purpose of securing financial support for this work, and as a result about $1,000 a year for three years was pledged. A friend of the college interested in work of this kind pledged $500 a year for three years.

In the summer of 1913 Mr. Elgin Sherk, a graduate of Syracuse University, and for some time secretary of the Syracuse University Y. M. C. A., was employed from funds thus secured by voluntary contribution. For over a year Mr. Sherk has been working among the college men organizing enterprises for social service, and in many other ways stimulating among the students a desire to become of service to their fellow men. Under his direction several classes of foreigners have been taught by our students in Three Rivers, Bondsville, and Thorndike. Several students also have charge of boys' clubs, and something has been done by the men in the way of conducting Bible classes in surrounding towns. Mr. Sherk has co-operated with the county work department of the State Y. M. C. A. in organizing religious work in some of the hill towns of western Massachusetts. Taken as a whole, Mr. Sherk and the work which he is undertaking has made a profound impression upon the students and upon the communities. It is hoped that in some way adequate financial provision may be made so that this work may be continued indefinitely.

The Athletic Field.

In June, 1913, the trustees set aside approximately 7 acres of land belonging to the college for the purpose of athletics and delegated to the joint committee on athletics the right to control the same and develop it as an alumni field. At that time there were practically no funds available with which to improve the land; accordingly, in December, 1913, the athletic committee began an active campaign for funds with which to put the land in proper condition for athletic purposes. The total contributed

to date is approximately $7,000, of which the alumni classes have paid about $3,000, the undergraduate students $2,000, the balance having come from friends of the institution and from profits of the college paper.

Work on the field was commenced in April, 1914, when the drainage system was put in. This work was practically all done by students free of cost; the students dug about 5,000 feet of ditch and laid the tile, thus underdraining all the lower portions of the field; the students also opened the brook on the east side of the area to insure an adequate outlet for the drainage system. It is estimated that the value of the work thus done by the students was at least $1,000.

In May, bids were asked for the contract for grading the field, the specifications calling for the moving of 25,000 cubic yards of soil. The grading of the field was completed in September, and the whole area fertilized and seeded before the winter closed in. The total expenditures, including the contract for grading, the cost of tile, seed, engineering, etc., made a total of something over $8,000. Several hundred dollars have been pledged, but not yet paid, and it is probable that within a few months the entire balance will be raised.

Thus the immediate need of the situation is met in a fairly satisfactory manner. However, it is still necessary to build a fence to enclose the field, and construct the running track and permanent stands for the seating of spectators. It is probable that the accomplishment of these projects will take some time, but the machinery is in operation which will doubtless bring the desired results within a reasonable period.

The Fraternity House Situation.

For thirty years prior to 1908 there were four fraternities at the college. Since 1908, when the more rapid expansion of the college began, additional fraternal organizations have come into existence so that now there are nine fraternities and an organization of nonfraternity men, known as the "Commons Club." Of the nine fraternities, six are branches of national Greek letter organizations. Simultaneously with the growth in the number of fraternities and with the enlarged enrollment of the college, there has developed a tendency on the part of the fraternities to

obtain control of houses which may be used for rooming purposes. In 1908 one fraternity had a house; at present seven of the fraternities and the Commons Club either own or rent a house in the vicinity of the college campus. The Phi Sigma Kappa fraternity is just completing the first house designed and built primarily for the use of a fraternity, and on plans approved by the trustees of the college. This house is located on Pleasant Street at the south entrance to the college grounds, and is an attractive and serviceable addition to the campus.

Co-operation with Springfield Y. M. C. A. College.

One of the marked developments in recent agricultural education is the training of men for special fields of service in the rural community. The Young Men's Christian Association has done particularly notable work in organizing its service for country and village boys and young men. This work is placed on the county basis, and the need for training these county secretaries has become pressing. To meet this need the Springfield Young Men's Christian Association Training College has inaugurated a course for rural work secretaries, and has sought the co-operation of our college, desiring that a part of the course shall be given here consisting largely of technical agriculture, agricultural economics, and rural sociology. Plans are under way for meeting this request and for eventually securing reciprocal exchanges of students of the two institutions.

Legislative Appropriations.

Inasmuch as the Legislature of 1913 established our income for current expenses covering a period of five years, no bill was presented to the Legislature of 1914 embodying requests for increased appropriations for these purposes. It is still necessary however, for the college to make annual requests for appropriations for new buildings and other special objects, and in 1914 three items were included in the budget: (*a*) agricultural building, including equipment, $210,000; (*b*) student dormitory, $35,000; (*c*) minor additions, $10,000. The Legislature granted the appropriation of $210,000 requested for the agricultural building. The contract for the construction of this building was let in midsummer, and the work is now well under way.

Exchange of Land.

The Legislature of 1913 passed an act authorizing the exchange of a portion of the college land acquired in 1910, and known as the "Louisa Baker Tract," and comprising about 12 acres, for 25 acres generally known as the "Owen land." The trustees, on November 6, voted to consummate the exchange, and the Governor and Council, on November 25, authorized the exchange. Steps are under way to carry out these in tructions. The college will thus acquire an area admirably fitted for the development of the horticultural division, bounded on three sides by the college estate, and completing a compact area of horticultural land. The college parts with land well adapted to the construction of residences near the college grounds.

Improvements, Repairs, and Construction.

Improvements and repairs this year have not been quite so extensive as in the immediate past.

The new piggery has been completed at a cost of $3,000, and another building, costing $1,000, has been added to the equipment of the poultry department. Some new cinder walks have been constructed, but the need for further extension of both cinder and cement walks is very pressing. An extension to the president's house of the 6-inch water main has been completed, thus giving adequate fire protection and further water supply to the cold-storage building, as well as to the president's house.

Steam has been carried from the pit south of Clark Hall to the Phi Sigma Kappa fraternity house, an arrangement having been made with the fraternity corporation whereby the college will furnish steam and electricity for this building.

There have been made the usual repairs and minor improvements necessary to the proper upkeep of the college buildings.

French Hall. — During the year work on French Hall has been completed. This provides somewhat more than double the classroom capacity formerly available in this building. French Hall is now one of the most attractive buildings architecturally, and one of the most serviceable, on the campus.

Infirmary. — The Legislature of 1913 appropriated $15,000 for the erection of an infirmary. For various reasons it was impossible to begin work on this building until the present fall. The plan finally decided upon includes one large building, with wards for patients and rooms for the matron and nurses, and a second building, designated as an "isolation ward." These buildings are heated and lighted from the central power plant. The plans embody the most modern ideas in hospital construction, arrangement, and convenience.

Agricultural Building. — The largest construction project undertaken during the year is that of the agricultural building and auditorium. When completed this will be the largest and most costly building on the grounds. The plans provide for a main building of three stories and basement, which will be devoted to offices, classrooms, and laboratories for practically all the departments in the Division of Agriculture, except that of dairying. It will be possible, also, to provide in this building for several other departments which at present are inadequately housed, both with respect to classroom facilities and office accommodations. In connection with this building there will be erected an auditorium, the seating capacity of which will be approximately 900; the auditorium will be used for general college exercises instead of the chapel, which has for several years been entirely inadequate for the demands made upon it. Shops for the Department of Rural Engineering are in process of construction.

Beginning on page 72 of this report will be found the following tables and statistics: —

IMMEDIATE NEEDS OF THE COLLEGE.

The Legislative Budget for 1915.

Your Board has already voted the following budget of special appropriations for presentation to the incoming Legislature: —

Addition to the power plant,	$30,000
Miscellaneous additions,	10,000
Student dormitory,	40,000
Laboratory for microbiology,	67,500

Following is a statement of the reasons for these applications for legislative appropriations: —

Addition to the Power Plant.

The college power plant has reached its maximum capacity. At present it can furnish steam for about 55,000 feet of radiation. The new agricultural building, in which the radiation foots up to approximately 15,000 feet, will add nearly 25 per cent. to the demand upon the heating plant. The present plant consists of four boilers of 150 horse power each, with a storage capacity for 600 tons of coal. It will take another boiler to furnish steam for the new building, but this addition leaves no reserve in case of emergency, and it seems advisable to install two new boilers, each of 200 horse power, with space for two more boilers eventually. To make these additions there must be a new storage pocket, a coal trestle, and a new chimney. Thoroughgoing estimates made by the Stone & Webster Company call for $33,200. We believe, however, that the changes can be made, by utilizing a good deal of our own labor, at a cost of $30,000.

The absolute necessity of this enlargement of our central plant is obvious. The new agricultural building which will be ready for occupancy in September cannot be utilized unless we secure additional heating power.

Miscellaneous Additions.

The college has recently established a Department of Rural Engineering, intended to cover the field of farm mechanics, farm machinery, farm power, cement work, roads, farm build-

ings, public rural engineering, etc. This is a line of work that has long been needed, and of course requires shop facilities. We are able this year to make a start by constructing one-half of one unit of the proposed shops; next year we should complete this unit. It will take about $2,500 for this purpose, and the final cost of the entire building will be about $15,000. Appropriations for this, however, can come later. The appropriation is indispensable in the development of this new and important department. The balance of the sum of $10,000 is needed for walks, refitting rooms in South College, and for installing a cold-storage plant in the dining hall.

Student Dormitory.

At present the college has dormitory facilities for about 70 students. The enrollment of students doing work of college grade exceeds 600. The demand for rooms in private houses has caused rentals at rates which in some cases are almost prohibitive to students, and particularly so to those students who are obliged to earn a part or all of their college expenses. The number of rooms within reasonable distance of the college, which may be secured at any price, is limited. It is uneconomical, from the standpoint of time, for a large number of students to live a mile or a mile and a half away from their college work. Furthermore, it is unsatisfactory from the standpoint of college discipline to have so large a percentage of students scattered over such a territory, as is necessary under existing circumstances.

The proposed dormitory, for which an appropriation has been asked for five successive years, will accommodate 50 men, and will be managed in such a way that students can secure good living accommodations at a comparatively reasonable cost. At the same time, the dormitory will yield to the college a fair financial return on the investment.

Laboratory for Microbiology.

Following are the essential reasons why a laboratory for the Department of Microbiology is a pressing need: —

1. At present there are no suitable facilities for giving instruction in this department to graduate and undergraduate students.

For a time the college has rented rooms over a mile from the college, and located in the center of the town, in order to make even inadequate provision for certain work of this department.

This is a comparatively new department, but represents one of the most important lines of agricultural science, and the enrollment in the courses is bound to grow rapidly.

2. Owing to the lack of proper accommodations it is impossible to carry on certain lines of laboratory and research work, such as, for example, investigations in milk, soil, and food microbiology.

3. A further handicap to satisfactory work is found in the fact that at present a room for the work is assigned in the dairy instruction building. Under these conditions it is impossible to work with any degree of freedom, because of the presence in the microbiological laboratory of obnoxious odors and the danger of introducing disease organisms into the dairy building.

4. The small amount of room now assigned to the Department of Microbiology is needed for the Department of Dairying, for which the building was originally designed and the demands of which are constantly increasing.

It seems unwise to build many small buildings, consequently the trustees have prepared plans for a building large enough to house not only the Department of Microbiology, but also the Department of Physics. This building when finally completed, it is estimated, will cost about $160,000. The north end is to be used for microbiology, and for this we are asking $67,500; this will enable us to house this department in good order. The building is to be fireproof, with two stories and a basement, and the appropriation includes proper equipment for teaching and research purposes.

The Graves Forest.

The Legislature of 1914 referred to the next General Court our request for an appropriation of $30,000 for the purchase of a tract of land on Mt. Toby, owned by Mr. John L. Graves of Boston. The committee on agriculture, after visiting the land, expressed a cordial appreciation of the desirability of the tract for college purposes. I cannot urge too strongly the early granting of an appropriation for this purchase. This area of over 700 acres of beautiful forest, with trees of all ages and in wonderful

variety, including the summit as well as one of the slopes of perhaps the most interesting elevation in our valley, forms the ideal laboratory for our Department of Forestry. The tract should be scientifically treated as a forest, and thus would serve for generations not only as a demonstration in a business of increasing importance, but also as a perpetual public reservation.

Continuing Appropriations for Improvements.

Two years ago the Legislature passed an act providing an annual income for the operation of the institution, increasing somewhat each year for a period of five years. This plan was developed under the initiative of the Commission on Economy and Efficiency, and at the outset it was believed that a similar arrangement could be made with regard to improvements. Certain matters, however, stood in the way at that time, and we are therefore still dependent upon special appropriations for the development of buildings and larger items for improvements and additions.

I wish to present for your consideration a plan for a fixed appropriation for improvements, including new buildings, sundry additions to the plant, new equipment, and land. Technical objections to this plan have, it is believed, been met in a bill drafted in consultation with the Attorney-General and the State Auditor.

The need for an enlarged income for additions to the physical plant at the college seems to us clearly obvious. Following is a provisional list of buildings and other improvements needed during the next decade, with conservative estimates of cost. Of course, we are assuming that the college is to grow during the next ten years, though perhaps not so rapidly as during the last ten years; but it seems wise to plan for at least a thousand students in the near future, and the equipment indicated is based on that figure: —

A Six-year Plan.

Complete rural engineering shop,	$15,000
Complete infirmary,	15,000
Laboratory, physics and microbiology,	160,000
Service building for pomology,	28,000

Remodeling Stockbridge house and cottage,	$14,000
Student dormitory,	40,000
Greenhouses,	15,000
Library,	250,000
Chemistry building,	235,000
Armory and gymnasium,	210,000
General improvements,	90,000
New equipment,	60,000
Land,	30,000
Other buildings suggested by faculty to meet early needs: —	
Minor farm buildings,	8,000
Instruction building for rural engineering,	80,000
Building for poultry husbandry,	80,000
Central building for administration, auditorium, and academic departments,	300,000
New dining hall,	200,000
Agricultural normal school,	30,000
Dormitories for 1,000 students,	800,000

There are many advantages accruing from a regular stated income for improvements. We can plan much more wisely than we can under the uncertainty arising from annual legislative action. Sometimes we are obliged to ask for buildings three or four years in succession, although the immediate need seems to us imperative. It is possible that when two buildings are requested we may be granted the building of lesser consequence. No doubt considerable economy can be effected by reducing winter work on buildings to a minimum. It is seldom possible to make contracts after the Legislature has adjourned, especially for large buildings, in time to permit contractors to house in the building before winter comes. Oftentimes departments are seriously handicapped because buildings are not completed at the opening of the college year, simply because we have not been able to start them in time. The State will be the gainer through this plan. Besides, if we are to maintain a first-class agricultural college we need a modern equipment and plant, well planned and consistently developed.

OUR PRESENT TASK.

During the past fifteen years the college has expanded steadily and rather rapidly. Many new departments have been organized; new subjects of study have been placed in the curriculum; the attendance of students has increased sixfold since 1898, and has nearly trebled in eight years; we are rarely without building operations in progress; the extension work has grown from very small beginnings to large proportions; a business and administrative organization has been built up; there has been a notable increase of income. All of these developments have constituted an era of expansion.

It seems quite probable that the college will continue to grow, and that new needs in material ways will continue to arise, but it is not likely that the next few years will demand expansion in scope and equipment in the same ratio as in the past. Our main problem now seems to be to enter deliberately upon an era of consolidation; to study our purposes; to improve our methods; to adjust parts to one another and to the whole; to secure a larger measure of co-operation among all the factors; in fine, to perfect our organization.

If this policy be the correct one, it seems worth while to outline in this report some of those subproblems that are involved in the attempt to secure this more compact organization of the institution, in order that all of us may have at least a framework for our thinking and our planning.

I shall attempt nothing more at this time than to name the main problems as I conceive them, and as briefly as possible mark out or define each one. I may say that in nearly all instances there is under way a more or less well-developed plan for the consideration of these matters.

Problems of Undergraduate Teaching.

I. Instruction.

The good teacher is the bulwark of every college. There has been an evident check in the tendency of educational institutions, in judging the qualifications of teachers, to place the chief emphasis upon research ability. The true teacher must keep growing; and to keep growing he must investigate, as well as

profit by the results of the investigations of others. But the primary task of the teacher is to teach, and ability in research is not necessarily a test of ability in teaching. Consequently, teachers who can teach, who can inspire, who realize that they are teaching men rather than subjects, who have personality and character, enthusiasm and ideals, constitute the fundamental college need. Such men are sufficiently rare so that the economic law of supply and demand has a very definite meaning to the institutions seeking high-grade men. We must pay better salaries if we wish to keep our better men. Nor can we in Massachusetts avoid the reflection that our real competitors for the best men, at least in the technical subjects, are the strong agricultural colleges of the great agricultural States. It is doubtless true, also, that as a faculty we should give more attention to methods of instruction. It may be denied that there exists a well-established agricultural pedagogy, but it is well for us to consider with care whether we are using the best possible teaching methods.

II. Courses of Study.

The recent vote of your Board of Trustees encourages the faculty to engage, in a most thoroughgoing way, in the task of discovering, if possible, a better curriculum than the present one, by which the purpose of the college may be carried out. The vote is as follows: —

> That the faculty be requested to make a study, and to prepare a report thereon, of the entire curriculum, with reference to its full adaptability to the training of students for the various agricultural vocations, and also in citizenship and in general culture.

This vote in a sense outlines our problem. In a college devoted to the interests of agriculture it is evidently intended that the course shall be avowedly professional. We are set to the task of training men for following those vocations connected with agriculture and country life. But it would seem, also, to be the clear duty of a State-supported institution to fit its graduates to take their places in the common civic life. And, furthermore, from the standpoint of training good workers and good citizens, can we avoid an endeavor to bring our students to see

the meaning of the personal life itself, its real import, and how it may be worked out to a successful issue?

Our present course is somewhat of a mixture of the old insistence on formal discipline and a thorough study of the sciences, of mathematics, and modern languages as foundations for professional work, and the newer insistence on technical subject-matter and training. Our course is also, perhaps, a compromise between the emphasis on the professional aspect of education and on the so-called liberal aspect of education. But, however all this may be, there are some serious questions that must be answered. For example, we cannot ignore the present dissatisfaction that exists on the part of the high schools in respect to college entrance requirements. We must answer the question, Are our own entrance requirements too rigid and formal? The development of agriculture of secondary grade raises another specific question of entrance — namely, Shall we give credit for this type of agriculture? The whole question of content of the course of study is still being raised. What proportions of our course should be given to strictly technical work, to the formal sciences, to the humanities?

These, however, are really subsidiary questions. The main problem is to discover, if possible, how we can organize a four-years course of study which will best train men and women for the various agricultural vocations, and, at the same time, give them some grasp upon the nature and scope of the problems which they must face both as citizens and as human beings desiring the largest possible development of mental and spiritual capacity.

III. Quality of Scholarship.

It is often asserted that the vocational or professional institution secures more thorough work from its students than is the case with the liberal arts colleges, on account of the interest aroused by the so-called utilitarian subjects. This is not necessarily true. I am sure that in our own institution the quality standards are not yet sufficiently high. There are many men, particularly in the upper years, who do not exert their energies to the fullest degree in classroom work; and of course the habit of doing less than one's best is absolutely fatal in developing maximum efficiency.

I wish it might be possible for us to have a closer oversight of the study-work of our students during the entire college course. We can never go back to the close supervision of the students exercised by the colleges of a century or a half century ago. But I think we have gone too far in adopting the German university method of letting the student work out his own salvation, particularly with the under classmen. The organization of a better method of supervision will undoubtedly require some money and the ability to command the services of men especially adapted to this sort of work. Our aim for quality of scholarship must not be quixotic. It must not exclude the faithful student of mediocre talent. Ideally, it will mean getting out of each student the best of which he is capable.

IV. Student Life and Activities.

This question is one of the most puzzling problems of our American college life. The so-called "student activities" have grown up, for the most part, without faculty initiative, sometimes with faculty opposition, and rarely with faculty oversight and approval. But they have worked themselves into the structure of college life. They have a distinct educational value because they encourage initiative, inventiveness, responsibility, and leadership. Our problem is how to adjust these activities to class work so that they may supplement rather than controvert the main objects of the institution, and may contribute both to the student's efficiency and character; and how to maintain freedom of student initiative and management and still such measure of faculty oversight that these activities become organic in the college scheme of training.

V. Physical Training of Students.

The American college has accepted the responsibility for the physical welfare of its students, but it has not developed the proper machinery for realizing the results of this responsibility. The fault is not wholly that of the college. The college student is boy turning into man. He still has the play instinct; but unfortunately he is often led astray by the romance of the splendid contests of highly trained representatives of his devotion to play. The ideal is that every man should himself partic-

ipate; he should constantly play the out-of-door games, and, if possible, such games as he can carry through life. Right teaching as to diet, temperance, personal purity are also part of our obligation to the student. In the last few years we have made substantial headway in this matter, but are not yet satisfied.

VI. The Housing and Feeding of Students.

In many colleges this question is entirely ignored by the college authorities. I question whether it ought to be ignored by any college. Under our present conditions we could not ignore it if we would. These conditions are unsatisfactory in many ways. The rooms occupied by the students are scattered over the village. There is no supervision. We have no assurance that the students are living under proper sanitary conditions; although it is only fair to say that the impression prevails that these conditions are satisfactory both physically and morally. But the present responsibility of the situation lies with the citizens of Amherst and with our students, rather than with the college authorities, because of the lack of any intelligent direction or supervision. The board at the dining hall seems to be satisfactory on the whole. But there are many questions that continue to arise. For example, shall we have a dormitory system? If so, how shall we get these dormitories, and how manage them? If we do not adopt a dormitory system, how may students be assured rooms, sanitary, properly conducted, at reasonable prices? It is highly desirable that the college itself should furnish board at cost, and should relate the management of the dining hall to the question of proper dietary habits on the part of the students. There is more or less self-boarding among the students who have to earn their own way. Nothing but praise should be given a man who does this, but there is a serious question whether such sacrifices are not actually deleterious in the long run.

VII. Character Building as a Special Endeavor.

It is sometimes said that the main object of schools and colleges is character building. Of course the main object of life is character building. The man who seeks the highest ends, either

consciously or unconsciously, makes all his experience minister to character building in himself and in others. But it is hardly correct to say that the objective of college work is character building in the sense of an immediate and special end.

But if character building may not be regarded as the immediate objective, it ought to play its true part; in other words, college courses and college life ought to minister at every point to the largest life of the man; so that every college that is true to its work has the task of so organizing itself that the student may not only have an opportunity to gain a broad view of the fundamental problems of life, but also have an opportunity for forming the best personal habits and for rendering some form of community service. In all this work a State institution must sedulously guard itself against infringing religious liberty or stirring religious prejudice.

Problems of Advanced and Special Study.

VIII. The Graduate School.

The college has recognized the dearth of thoroughly trained men for investigation, for teaching, and for expert service in agriculture and country life fields, by establishing a graduate school which now has an enrollment of over 50. But we still have many questions to face, such, for example, as the extent to which the graduate work shall be developed, the degrees to be offered, the relationship to undergraduate work, our ability to finance probable developments, the provision of teachers, and the correlation of research with graduate study. The report of the director (page 50) furnishes an admirable outline of the present organization and of some of our problems.

IX. School for Rural Social Service.

Future leadership in agriculture and country life lies not only with men and women who are experts, or investigators, or teachers in the field of technical agriculture and the sciences underlying it, but equally with those men and women who design to become leaders or experts — in local community, in the State, in the nation — in the realms of rural education, rural politics, or rural organization. The agricultural colleges

are already contributing, and are destined to contribute even more completely, to the training of teachers in secondary agricultural schools, of country clergymen, of rural Y. M. C. A. secretaries, of rural librarians, of grange workers, and of other leaders in the country-life movement. It is worth our while to ask if this field is not extensive enough to warrant the organization on our campus of what is practically a School of Rural Social Service. It is quite possible that such an enterprise can come to its fullness only with private endowment supplementing the efforts that we find practicable as a State institution.

X. The Training of Women for Agriculture and Rural Home Life.

There is a new demand upon the part of young women for participating with men in the training for the agricultural vocations. So far we have not met this call in any adequate way. We can hardly neglect for long this increasingly important and reasonable demand. But this is not the only phase of the relationship of the college to the needs of women. Heretofore the movement for better agricultural education has not given sufficient attention to the rural home. Successful departments of domestic science have been instituted in many of the land-grant colleges, and these departments are doing notable work. In popular agricultural education, that is, through farmers' institutes and extension service, a great deal has been done on behalf of the country home. But we have yet to meet the problem in its full need. In the last analysis woman's status on the farm and the quality of the home life in the country, are the determining factors of a permanent rural civilization. It would seem, therefore, that such attention should be given to the problems of the rural home as is given to the problems of the farm itself. I hope, therefore, that we may consider the organization on our campus of courses that shall form virtually a Woman's College of Agriculture and Rural Home Life. I do not wish to raise the issue of coeducation, and it is not necessary, for the device of an affiliated woman's college has proved workable in other New England colleges.

Problems involved in Agricultural Investigation.

XI. Development of Research Work.

The need of continued and thorough investigation of the main elements of the agricultural problem requires no elaboration. Research is fundamental to fresh teaching. Indeed, it is fundamental to the complete development of the college as the servant of the agricultural interests of the Commonwealth. The field of research broadens as we appreciate more completely the scope of the rural problem, and the possibilities lying before an educational institution in helping to solve that problem. The vital element in planning this task of investigation, which includes both thoroughgoing scientific research and practical tests and experiments, is to determine the problems of agriculture and country life that most need attention. The eyes of every investigator should be on this issue. Investigation, no matter how interesting for the individual investigator, should square with the most significant needs of the people who till the soil.

Up to the present time, research and experiment in our agricultural colleges, as developed through the work of the experiment station, has been largely in connection with the study of the soil, and the plant, and the animal — their characteristics, the laws that operate in their utilization, and their interrelationships. Soil fertility, the relation of crops and soil to climate, improvement of soils, improvement of crops and animals, and better feeding and care; protection from diseases and pests; and greater facility in the use of natural powers — these have been the field of research. There is still illimitable opportunity and need for sound work here. We have found, however, that our rural problem is not only a question of improving the farm, but also of improving the business and even the life of the community. If we are to fulfill our mission, therefore, we must also undertake thoroughgoing studies of farm management, and of those conditions in the economic and business world that affect the farmers' welfare, such as the securing of sufficient capital, more effective methods of purchase, more satisfactory methods of sale, and, in general, the attainment of a clearer understanding of the economic affairs with which the farmer must deal. But there are also social forces which affect very

materially both his business and his welfare. Therefore the conditions under which he works and lives, his home life, his community life, his education — all need the study of the trained mind.

We face, therefore, the problem of a rather wide extension of the field of agricultural research, simply because we have come to realize that the physical and biological forces with which the farmer deals constitute after all only a part of his problem. The economic and social forces are equally compelling in the development of his business.

XII. An Agricultural Survey.

The extension of the field of agricultural research just referred to suggests a specialized phase of investigation which is now seen to be of the utmost importance. For want of a better name we call it "an agricultural survey." In general research and experimentation we have to do with fundamental forces and principles. An agricultural survey takes into account actual conditions which the working farmer has to meet on his own farm. This distinction between the two types of investigation is not quite so sharp as might appear at first; but, in general, it will serve as a definition. A closer study of soils and climate and other physical factors, with reference to their adaptability to certain types of farming; the study of transportation and markets; the facts in regard to cost of production and cost of distribution are illustrative of this phase of investigation. We already have under way a considerable amount of work in this field, especially in the subject of farm management in co-operation with the United States Department of Agriculture. But we cannot expect Massachusetts agriculture to develop as rapidly as it may until we can furnish farmers with exact facts concerning the conditions under which they actually have to operate their business.

Problems of the Extension Service.

XIII. Extension Teaching.

It is unnecessary to dwell upon the importance of extension teaching in agriculture. Not only has our own policy become thoroughly established, but we have developed an organization

and a method that I think will bear comparison with that of any agricultural college in the country. More than that, the whole movement for extension teaching has been given a new impetus by the passage of the Smith-Lever act of 1914. This act as certainly the most stupendous and, I believe, the most significant and statesmanlike piece of legislation of its kind ever enacted. It means the nationalization of popular agricultural education. If all the States comply with its requirements the income from both State and national treasuries will eventually be the equivalent of 4 per cent. interest on an endowment of $200,000,000. Massachusetts does not get its full share of this fund because of our small "rural population." Our own problems, however, are sufficiently difficult and important. We should study our administrative organization, our types of work, our methods of teaching, etc. Extension work is confessedly young. In a sense, we have been experimenting. These subjects should receive as much attention during the next few years as any other phase of institutional work. I should like to call attention to the recommendations of the Director of the Extension Service in another part of this report (page 61), and especially to urge careful consideration of our relation to the so-called "county-agent" work.

It is clear that all this work will require larger funds than the State is at present appropriating. We must be cautious, of course, not to advocate extravagant expenditures for this line of work; but, on the other hand, we must not fail to make it clear that if wisely used the cost of an efficient extension service is not a tax but an investment.

XIV. The Place of the College in Rural Organization.

During the last few years we have made great strides in our conception of the rural problem and how to meet it. We have discovered, for example, that this problem is both broad and complicated. As Sir Horace Plunkett, the great Irish leader, so happily expresses it, we need "better farming, better business, better living." And not only have we learned to look upon the rural question as a unit, but we have learned that we must attack it in its entirety. We must correlate the work of institutions, we must prevent overlapping, waste of effort due to duplication,

and friction that sometimes arise in the conflicts of institutional interests. In other words, we should have a rural policy for community, for State, and even for the nation as a whole. This policy involves a study of the larger phases of the rural problem, a division of labor among institutions and organizations, a correlation of effort on the part of all agencies interested, and consequently a complete rural organization.

Our own college is participating in a movement of this sort which is still in a formative stage, and which yet bears the marks of a comprehensive attempt at securing a rural policy. We are assisting communities to make plans for community development; we are participating in the Massachusetts Federation for Rural Progress, which aims to correlate all rural activities; we are assisting in the establishment of county improvement bureaus. All these efforts involve us inextricably in the problem of general rural organization. We must establish our proper relationships with other institutions and agencies. We have made progress in this direction in recent years, but the whole matter still constitutes an important problem.

Problems of General Administration.

XV. The Administrative Organization of the Institution.

In this day of demand for efficiency, and in this country of administrative skill in business, it is easy for an educational institution to overorganize itself, or to attempt unwisely to transfer administrative schemes successful in business to the college campus where they may have no place. On the other hand, in avoiding "red tape" there is a temptation to neglect proper administrative organization, especially in the smaller institutions, thereby losing headway and energy.

The principles of good administrative organization for a college would seem to include, among other things, a clear definition of the function of the various administrative elements, such as trustees, faculty, administrative officers; the formulation of adequate codes of by-laws for the trustees and the faculty; the centralizing of administrative responsibility in a few hands; well-recognized committee responsibility both in trustees and faculty; democratic methods of establishing policies; the develop-

ment of standard efficiency tests; a simple but thorough system of reports; the reduction of rules and formulas to the lowest possible terms.

XVI. Business Organization and Efficiency.

There can be no question about the responsibility that rests upon every member of the staff of this institution to utilize the really liberal funds which the Commonwealth has granted for our use in a way to make every dollar count to the fullest. Here, also, there is a need for some standard tests of efficiency, but these tests are difficult to make. The business man can test the use of his money by money results; but the last thing that accrues from the use of money in an educational institution is more money. The business question that we confront is not greater profit, but simply the wisest possible use — wise not in terms of money results, but in terms of effective teaching, of useful investigation, of helpful extension service. It is not easy to formulate the ideal plan of business organization. The terms of employment, the supervision of the purely business aspects of the institution, the best methods of apportioning funds, complete but simple reports of the use of funds, the increasingly important question of clerical help, the relation of the institution to members of its staff with respect to professional improvements, attendance at important meetings, etc., are all pressing questions.

We have developed a very complete system of bookkeeping at the college, but it is a question whether any educational institution has yet developed an adequate system of accounting. Most of the attempts that have been made to establish a satisfactory scheme for cost accounting when applied to an educational institution merely emphasize the difficulties involved. It would hardly seem that the problem is an insoluble one. At any rate, it is our duty to seek a solution.

XVII. Securing and Maintaining an Adequate Physical Plant.

A college does not consist of brick and mortar. But it is a mere platitude to say that if a college is to do its best work it must be properly housed. We must develop an adequate physi-

cal plant to house our various departments, so arranged that it conforms to accepted principles of landscape gardening and architecture, and secures a maximum of convenience and permanence. The problem of the character of buildings is also involved. The best methods of planning them and erecting them, the question of types of buildings — whether fireproof or not — the matter of care, repairs, janitor service, fire protection, are all important. It is impossible to lay out a building program for any appreciable term of years. A great deal depends upon the growth of the college in students. Much depends, also, upon the adjustment from time to time of departmental work, the institution of new departments, etc. I have outlined elsewhere in this report the early needs of our plant on the physical side, so far as I can foresee them. Tentative plans have already been prepared for some of these buildings.

XVIII. Publicity.

The time for advertising a college like ours has gone by; that is, advertising in the commercial sense of the word. There is no dearth of students, and the best advertising is the work we do and the men we graduate. But in my opinion it is our duty to develop a system of publicity for the institution that gives, through the newspapers, through public lectures, and through special publications, an adequate idea of the service which the institution is rendering, and can render, to the people of the Commonwealth. The motive of merely advertising ourselves may be honestly disavowed, for a State-supported college should help the people of the State to understand and utilize the opportunities which the college offers to those who need its help. It is a strange fact that to-day, with such publicity as has already been given to the college, there are thousands of people in Massachusetts who do not know to what extent the college can help them, nor how to obtain the information they want.

XIX. Adequate Financial Support.

The question of financial support for this institution may be put in an interrogative sentence: Is the Commonwealth of Massachusetts willing to make appropriations sufficient to sup-

port a *first-class* agricultural college? Without question the people are willing to support a *good* agricultural college. The Legislature during recent years has increased our appropriations generously. Assuming that we are administering wisely the funds intrusted to our care, the question still arises, To what degree can we count upon further support? The question involved is not merely that of the willingness of the people to make larger appropriations; it is also a question of the ability of the State to sustain all of its public institutions in proper fashion, and at the same time adequately to support a first-class agricultural college.

I take the liberty of quoting from my inaugural address, made eight years ago, a few sentences covering this question: —

> To carry out the forward movement in agricultural education much larger appropriations of money than are now available must be granted by the State. Indeed, this is, on the practical side, the prime question that confronts agricultural education. Thoroughly trained investigators are not common, but they can be had; there will be no lack of attendance at agricultural colleges; there is no inherent difficulty in interesting farmers in extension work. In fact, the forward movement in agricultural education in most States of the Union now waits very largely upon one consideration — adequate appropriations. The difficulty of the problem before the Massachusetts Agricultural College is measured, I take it, very largely by the degree to which the public sentiment of this Commonwealth, as expressed through the Legislature, will stand sponsor for a program that attempts to forward in the most thorough way the vital rural interests of the State.

I still maintain this position. And in this connection I ought to say that I do not believe that the Massachusetts Agricultural College should attempt to emphasize all the lines of work that are developed in western agricultural colleges. There are two things essential to the maintenance of an agricultural college of the first rank in this State. The first essential is to cover those subjects of study and investigation that are most intimately related to the fundamental agricultural and country-life problems of the Commonwealth. The second is to maintain high grade quality of research and teaching in those lines that we do attempt. Now the agricultural field, even in Massachusetts, is broadening very rapidly. Efficiency costs, in college teaching and

research as well as in business, and the people of the Commonwealth ought to know that if we are to continue to have an agricultural college of the first rank, it will take a great deal more money each year than is now being appropriated for our use.

I am inclined to the view that we must look for private endowment to supplement appropriations of public money. For example, take the matter of dormitories. College students cannot be housed in good dormitories at a cost much less than $800 per capita. This is lower than most eastern colleges allow. Suppose we take the lower figure: assuming an attendance of 1,200 students at this institution by the end of another decade, it would cost nearly $1,000,000 to house them in dormitories. If we had no other demands, possibly the State would be willing to spend money for this purpose. Doubtless the State is willing to do something, but I believe that private funds must come to our aid if we are to develop a complete dormitory system. There are other needs. In the west there has been a marked tendency in recent years for individuals to give large gifts or to leave large legacies to State institutions; it is not so customary in the east. Yet with the new interest of business men in agriculture and their realization of the importance of training a fine body of rural leaders, I venture to hope that we may expect substantial aid from private sources.

XX. Esprit de Corps.

In one sense this is our crowning problem. How shall we secure such a spirit in a large body of men employed at an institution of education that they shall work together intimately and sympathetically, co-operate for the best interests of the institution as a whole, subordinate departmental pride and personal ambitions? Great results are possible even though the administrative and business organization be defective. But on the other hand, no matter how fully the machinery for administration and organization be elaborated, unless there is the spirit of the whole body — the spirit of co-operation, the spirit of fraternity — no administrative scheme will work to advantage. We have here, in common with other institutions, the problem of the development of an *esprit de corps* among the faculty

and students, in their relations one to the other and in their relations to the trustees, the alumni and the public, that shall make the institution notable for the co-operative spirit.

In Conclusion.

I have stated a number of our problems without attempting to offer much in the way of an indication of their solution. I have merely tried to place before you an outline of our present task as I see it.

If during the next few years we can succeed in studying with some degree of thoroughness each one of these twenty problems; if we can in each case define the central aim and purpose, gain a clear-cut idea of present deficiencies, agree on principles of reconstruction, and put into operation a few practical methods, we shall have accomplished a great and enduring work. If I might be permitted a bit of sentiment and the announcement of a slogan, it would be to suggest "Massachusetts Agricultural College, 1920," with the hope that by that year we may have made reasonable progress toward the solution of these significant college problems.

KENYON L. BUTTERFIELD,
President.

REPORTS OF OTHER ADMINISTRATIVE OFFICERS.

IN THE DEPARTMENTS OF INSTRUCTION.

The Dean.

On account of my duties as acting president the bulk of the work in the dean's office this year fell upon Dean Mills and Miss Christiansen, most of it necessarily upon the latter. I gave a few days now and then to disentangling some of the more difficult questions. Dean Mills was not strong; consequently, he limited himself in the main to applications for absences from the regular college exercises. The work of handling students deficient in scholarship was in part carried by the chairmen of the freshmen and sophomore teachers' meetings. During the last two months, on account of my absence from college, Professor Mackimmie shared with Miss Christiansen the duties of the office.

EDWARD M. LEWIS,
Dean.

Division of Agriculture.

During the year there has been an increasing demand for the work of the members of the division, both from students and the people of the State. The appropriation made by the last Legislature for an agricultural building is an indication of this demand, as well as of the desire properly to house and equip the departments that deal so directly with technical agriculture. This spirit is further shown by gifts of valuable young pure-bred animals from several Guernsey, Jersey, and Berkshire breeders. These are valuable additions to our teaching equipment in animal husbandry, and are much appreciated.

The Department of Rural Engineering has been established during the year and fills a long-felt want. An additional instructor in dairying and a graduate assistant in animal hus-

bandry have been added to the staff. A veterinarian from the Bureau of Animal Industry, United States Department of Agriculture, has also been detailed for work in hog cholera prevention in the State, and will make his headquarters with the Animal Husbandry Department. On the college farm a small but well-equipped piggery and a silo at the young stock barn have been built.

Among the important and pressing needs of the division is a small appropriation for the completion of the rural engineering shops; also land fairly accessible to the college for the experimental work in poultry husbandry, and within driving distance for pasturage for young stock. Modern tools for demonstration on the college farm are also urgently needed; the college should lead and not follow in this respect.

Among the problems needing solution, the question of farm practice for our students should be mentioned. The last annual report of the college shows that while agriculture or horticulture is the intended vocation of over 80 per cent. of the entering class (1916), only 24 per cent. of the class were brought up on a farm, and only 61 per cent. had had any farm experience. This is a condition that needs careful attention if all our graduates are to gain and hold the confidence of their associates in the communities to which they go.

Another matter needing attention very soon is the proper correlation of the teaching and research work. Every department of the division should be devoting some attention to research work, and be prepared to investigate the many new problems that are being continually presented to us and which are still awaiting solution.

J. A. Foord,
Head of the Division.

Division of Horticulture.

No changes of special importance have been made in the organization or policies of the Division of Horticulture. The work has grown in volume and has been strengthened at various points. The sudden death of Mr. Georgia left the work in market gardening disorganized, and has made necessary the temporary suspension of one of the courses in market gardening. The

completion of French Hall has added greatly to our facilities, especially in providing room for market gardening and forestry.

There are many pressing needs in the Division of Horticulture, and it is hard to make a list of those which should be particularly emphasized. At the present moment the following seem to me the most important: (1) a small laboratory for the Department of Pomology, to house the work in manufacturing and to provide a laboratory for rough work in spraying; (2) an additional high-grade instructor to take the courses in general horticulture; (3) an adequate tract of forest land for the Department of Forestry; (4) the reorganization of the market-gardening work in a large way; (5) additional greenhouses.

The most serious problem which we have to meet is that of adjusting our instruction in technical subjects to the awkward college calendar. This matter has been mentioned under this same heading in previous reports. It would seem now that the college is in a position to make a change in its calendar, whereby instruction can be given throughout the year. If this change is reasonably well managed it will result in great good to the instruction in several technical lines. The instruction in technical or professional lines needs constant and thoroughgoing improvement. This is a matter which has received quite insufficient study in the past.

F. A. Waugh,
Head of the Division.

Division of Science.

Reports from the eight departments which comprise this division indicate that in nearly all of these larger classes are being taught than last year. Some changes and revisions of courses have been made to advantage, and the routine work has progressed, as a whole, in a satisfactory way.

As a result of the increase in size of the classes it has become more difficult to give them proper attention, particularly in laboratory work; and this condition, if continued, must result in more assistance, and, in some cases, an increase in the amount of funds available to supply the added equipment and material.

The fundamental problem in chemistry appears to be how to obtain the larger accommodations necessary for the best work.

In botany a better co-ordination of the courses is desirable. In entomology the problem of new courses is being studied, in order that undergraduate students may receive instruction comparable with that offered elsewhere in amount and range. At present several more subjects should be offered by the department if it is to compare with other places to advantage. In microbiology the need for adequate and properly equipped accommodations is the most pressing problem. A "laboratory where the simplest microbiological matters to the most complex can be taught and demonstrated" is much needed.

The real problem confronting all departments, not only of this division but throughout the college, is that of improving the attitude of the student to his work. The average student seemingly entirely fails to realize that any work on his part will be needed in order to support himself after graduation, and therefore he also fails to realize that here is the place to equip himself so that he will be most efficient later. When a student can be taught to realize the severity of the struggle for existence and that the man most adequately prepared is the one who will win, he will begin to take a college course more seriously and equip himself better for the struggle to follow.

H. T. Fernald,
Chairman of the Division.

Division of the Humanities.

Progress. — 1. There has been some increase in the number of students electing the strong courses in the division, due apparently to the improvement of the work.

2. The concentration of more instructors and classes of the division in French Hall, where the head of the division can keep in closer touch with the work, is a decided benefit.

3. The rearrangements in the department of English which were put into effect this year are all beneficial to that work, bringing about greater satisfaction to instructors, better team work for the department, and closer adherence to the schedule.

Now that Dean Lewis has been made permanent head of the department we can make more progress away from the confu-

sion of the past. His genius as an instructor in literature should be used in the department to the fullest extent of his time.

4. Professor Smith got good results from his work with the debating teams last spring, and he is now working on broader lines for the development of more debating material. The general problem of debating in the Massachusetts Agricultural College has not yet been solved, and we should watch Professor Smith's efforts with interest, and be ready to give assistance or make reforms on the basis of his experience.

5. Miss Jefferson's course in the history of New England seems to have aroused the enthusiasm of the instructor and the interest of the student. She will evidently "make good" in this, and is already advocating an extension of the work over two semesters. I think that one semester is sufficient for it at present.

Immediate Needs. — 1. Concentration of the instructors of the division within one building or one part of the campus as soon as possible, and the permanent location of each department in order that material may be collected and construction carried out for more efficient teaching.

2. New courses recommended: (*a*) Constitutional Government; (*b*) Local Government; (*c*) Philosophical and Religious Ideals; (*d*) Business Law and Administration.

The past experience of the division with the courses in history and government show that only first-class men should try to teach these courses, which most of the students ought to take, but which must compete in election with the vocational lines of work.

General Problems. — 1. To develop "better quality" of work rather than to extend the quantity and number of courses.

2. To build up an atmosphere of scholarship and academic interest within the division and college.

ROBERT J. SPRAGUE,
Head of the Division.

Division of Rural Social Science.

There have been no radical changes in the work of this division. Professor Eyerly's resignation has somewhat broken up the work of the Department of Rural Sociology, but three grad-

uate students, Mr. Russell F. Lund, Mr. Carl J. Strand, and Mr. Charles G. Baird, have carried on certain courses with enthusiasm and skill.

The extension service for boys and girls in the Department of Agricultural Education has grown to enormous proportions under the immediate supervision of Professor Morton, as will be shown by the report of the director of the extension service.

Prof. E. L. Morgan, in his work in stimulating and directing the rural community-building movement, is doing what I regard as perhaps the most significant constructive rural work that is being undertaken in this or in any other country. The rural community must eventually be the unit of rural development. I regard it as a great privilege that our institution should be foremost in recognizing and developing this fundamental principle.

KENYON L. BUTTERFIELD,
Head of the Division.

General Departments reporting to the President.

MILITARY DEPARTMENT.

Capt. George C. Martin reports as follows: —

At the present time and during the past year the regiment has been divided into two battalions of four companies each and band. The companies average about 50 men. During the year all members of the three lower classes have drilled, and 15 members of the senior class, a total of 429.

The general instructions from the War Department have been fully complied with. Three hours of practical work per week during the drill period is required of all students in the department. In addition to this, work in theory is required of the sophomore and freshmen classes for one hour each week during the scholastic year.

Also during the year the professor of military science and tactics has given lectures on such subjects as — Military Instruction in Colleges, Infantry Training, Military Courtesy, the Flag, Patriotism, and Military Policy of the United States.

Great interest is taken in rifle practice. The indoor rifle team won second place in this year's match. This was the greatest year for indoor shooting since the starting of the inter-

collegiate matches. Intercollegiate records were broken several times during the season both by Michigan, the winner, and by this college. That we lost the championship, due to the splendid shooting done by Michigan, does not decrease the interest in indoor shooting. This was shown by the students when they requested the Athletic Board to make indoor shooting part of the class sports for the sophomore and freshman classes, and the winning class will be granted their class numerals.

On the outdoor range this college won the championship from the strong Naval Academy team, both teams beating the intercollegiate record.

An encampment of a week or ten days is one of the greatest needs of the department. A new armory is badly needed; the present one is inadequate in every way for the number of students under instruction. There is a dangerous crush on the dismissal from drill, when the students are in a hurry to put up their arms.

Fifteen men were reported to the adjutant-general of the army and to the Adjutant-General of the Commonwealth of Massachusetts for special aptitude in the military service. The best 7 were recommended for commissions in the United States army.

The equipment of the department is of the best and in fine condition. The spirit of the young men is of the best, and many take great interest in the work of the department. The discipline of the regiment is excellent.

An additional short outdoor range is greatly needed. This should be near the college. As it is now, Saturday is the only day when students can get a chance to practice on the outdoor range, on account of the distance from the college, — about 2½ miles. If there were a 200-yard range near the college it would materially increase the interest in outdoor shooting, and consequently the number of men to qualify as expert riflemen, sharpshooters, and marksmen would be greatly increased.

The indoor range is inadequate for the number of men who wish to participate in the indoor shooting. It will only accommodate 4 men at a time. At any time in the afternoon during the last month there have been from 2 to 10 men waiting their turn in the gallery.

Department of Physical Education and Hygiene.

Professor Hicks reports as follows: —

The work of the department has been conducted during the past year along the following lines: —

1. The entering class of men were each given a physical examination during the first month of the college year, thus reducing the possibility of any injury arising from ignorance of their own condition. In the examination especial care is taken to detect any defects of the vital organs, sight, and hearing. Each person is given a short talk, following his examination, concerning his condition, the kind of exercise he should have, and the proper care of his body.

2. The freshman class is given a course of lectures and written quizzes on personal hygiene during the first semester.

3. The department during the past three years has been gradually increasing its service to students suffering from minor injuries or illness, advising calling of a physician when necessary, and seeing that ill or injured students are properly cared for. This work has developed until nearly every case of illness in the college is handled through the office of the physical director; we have estimated that during the past year more than 500 cases have received first-aid treatment in the department, and over 100 calls have been made on ill or injured students at their rooms, to see that they are properly cared for and given such assistance as is necessary. We believe that by reaching these men in this way many cases, which have been previously neglected until serious, are now taken care of without any, or at most very little loss of time to the student. The possibility of any contagious disease becoming widespread before detection is also greatly reduced. In this work the department has been constantly in touch with the department of microbiology, through the health committee of the college.

4. During the winter months the department requires three hours of physical exercise per week of each member of the three lower classes. Those men who have been found by examination to be physically normal are permitted to elect one of the several athletic activities; those who have been found to be below normal physically are given individual instruction. Walking trips may be substituted for physical exercise in the gymnasium

and during the past year about 150 students elected this form of exercise. The work of the indoor classes of from 30 to 40 men each consists of gymnastic exercises and such games as basketball and indoor baseball.

The physical director is general manager of athletics, supervising the arrangements for contests with other colleges, buying the supplies for the teams, assisting in the coaching, and having final control of the players and games.

The interest in intercollegiate and intramural athletic activities has been steadily growing. An accurate estimate of the participation in all sports during the year shows that in track 55 men participated; cross country, 25; hockey, 75; baseball (including interfraternity), 175; tennis, 25; football, 90; and basketball (other than required gymnasium), 40. After counting out duplications we find that approximately 45 per cent. of the student body voluntarily took part in some form of supervised athletic sport during the year.

The limited quarters in which the regular gymnasium work is to be carried on during the winter season make it impossible to do indoor gymnastics which compare in anywise favorably with that of other colleges. From December 1 to the coming of spring the drill hall floor is in use until 9 o'clock every night. The need of a larger gymnasium with proper bathing facilities is great.

Library.

Mr. Green reports as follows: —

The very pressing need for a new library building overshadows every library activity, and influences, without question, the work of a good many of the departments in the institution. The lack of adequate accommodations for library workers is so evident that teachers and students alike are discouraged from making good use of our equipment. Lack of room for the proper accommodation of book material debars us from obtaining and making easily available good material which we ought to have on hand. Worse than our poor working accommodations or the impoverished book collection, is the serious absence of a fine library atmosphere — that intangible something so earnestly desired, and which would mean so much to those of our people desiring to use the college library.

There have been 3,337 volumes added during the year, making a total of 44,406 in the college library, 14,197, or nearly 33 per cent. of the books in the library, having been added during the past six years. The work of recataloguing the library continues as rapidly as possible, and is indicated by the new card catalogue in the process of making, which contains 61,413 cards for the 21,587 volumes recatalogued, and the 10,824 new volumes catalogued since this work began in April, 1910.

The regular library extension work in lending books on agriculture and related subjects to the small public libraries in the State continues, and has been supplemented by the publication of eight library leaflets on beekeeping, live stock, forestry, civic improvement, flower gardening, co-operative associations, marketing farm products, and farm and garden papers. Our records show that 760 books and 241 bulletins were loaned out during the past year to 42 borrowing libraries in the State.

Director of the Graduate School.

Organization of the Graduate School.

General.

The organization is based upon —

1. The recognition of the department as the unit.

2. The qualified individual instructor or instructors within the department as the directive agents.

3. The apprenticeship system of instruction; that is, the clustering of one, two or three graduate students about every qualified instructor in the department and in the college for intimate study and experience.

Organization.

4. A committee, consisting of the instructor having the major subject of the graduate student as chairman, and such a number, as may be determined by the director, of the instructors having the minor or minors or supporting courses of the graduate student as associates shall be appointed to advise the student, supervise and control his work, subject to the approval of the "graduate staff."

5. The assignment of a graduate student to an instructor shall be left with the director and head of the department in which he elects his major courses.

6. Should a graduate student be admitted as a candidate for no degree and fail to designate a major course, the director shall appoint a committee to act in the same capacity and to have the same power as if a major and minor had been chosen.

7. The "staff of the graduate school," or the "graduate staff," shall consist of the president of the college, the director of the graduate school, and the instructors who are chairmen of graduate students' committees, or who are in immediate charge of major subjects or courses, and the chairmen of those committees supervising graduate students' work, not candidates for a degree, subject to the approval of the director and president.

8. The staff of the graduate school shall be directly responsible to the president and Board of Trustees, except in those matters which the president may deem desirable to treat conjointly with other staffs and faculties, as general policies, before submitting them to the Board of Trustees.

Some Essential Details and Policies.

9. Because of the possible value of the work of graduate students to the State, it is urged that no tuition be charged, whether acting as graduate assistants or not. Further, that unless laboratory fees are such as arise in connection with undergraduate subjects, which are outside of major and minor subjects, they also will be remitted.

10. The number of graduate assistants shall be increased to that point where the educational work of the college or the investigations of the station will not be injured.

11. It is urged that the departmental courses of study for graduate work be left with the staff, subject to the approval of the Board of Trustees as formerly.

12. Major and minor courses leading to the degrees of Master of Agriculture and Doctor of Agriculture, or such specific degrees as may hereinafter be determined, shall be formulated in the practical departments of the college. In these courses basic systematic work in the sciences and practices, along with actual technical experience, shall be the distinctive purpose. Proficiency in practice shall be the highest ideal. The formulation of such courses shall emanate from the various technical departments, shall possess uniform requirements and standards, and

shall be submitted to the graduate staff for action, which in turn will transmit them to the Board of Trustees for approval.

13. Since exchange with other institutions is highly beneficial to graduate students, it shall be the duty of the director and staff to foster it in those cases where it is pertinent and valuable so far as is compatible with the interests of our own institution. In case a graduate student cannot secure at this institution what is essential to his work and training, it shall be the duty of the director and staff to arrange for such elsewhere.

14. Every graduate student must satisfy the graduate staff with a certain amount of practical agricultural knowledge and training, the amount, kind and quality to be determined by the staff.

Immediate Needs.

The most pressing needs of the graduate school are, in general, better facilities and equipment in conducting work of the highest grade. In some instances this lack of equipment is in the direction of the number of highly trained men to give the desired instruction. In other cases the lack is in proper laboratory equipment. Some of the departments are already adequately equipped to carry on work of the proper standard, and an excellent start has been made by them in placing this institution in the forefront with respect to scientific training along certain lines. The number of men that we try to train, however, should not exceed our ability to do our best work in securing the desired results.

Fundamental Problems.

Some of the fundamental problems which are at present most noticeable are: (*a*) A clarifying of the atmosphere as to what is agricultural research, graduate and undergraduate instruction, agricultural extension. (*b*) A development of a real, basis spirit of agricultural research, instruction, and extension as distinct from and in connection with the popular exhortation; in other words, we should not lose sight of the structure from which we unfurl our flag. (*c*) A possible confluent policy by which graduate theses may be strengthened by experiment station support with graduate requirements.

CHARLES E. MARSHALL,
Director of the Graduate School.

Supervisor of Short Courses.

All of the short courses given in previous years, except bee-keeping, with some additions, have been held during 1914, increased popularity and enrollment being shown. In fact, the registration in short courses has reached the point where the facilities of the college and satisfactory living accommodations in the village are overtaxed, and careful, immediate consideration must be given to the problems arising from the continually increasing attendance at these courses.

We have had the hearty co-operation of several State and national organizations in arranging programs. Among them are: —

Massachusetts Board of Education.
Massachusetts Civic League.
Massachusetts State Grange.
State Board of Health.
Massachusetts Free Public Library Commission.
Massachusetts Federation of Churches.
State Forester.
Massachusetts Forestry Commission.
State Board of Agriculture.
Massachusetts Dairymen's Association.

In the near future it is planned to arrange short courses of three or four days in length at the college for such groups as feed dealers, fertilizer agents, milk inspectors, seed dealers, town officers, boards of health, and others whom the college may serve. Programs have been prepared and dates have been set for meetings for feed dealers and property assessors during the coming winter.

Following are some of the problems concerning short courses which I desire to present to you and the trustees for early consideration: —

1. Inasmuch as the college is receiving an increased appropriation each year, and since the short courses are to be considered as a part of the teaching of the college, the cost of maintaining them should be borne by the college. With a stationary appropriation for the next four years it will not be possible to take care of increased enrollment from extension funds. The need of larger appropriations for the summer school and Farmers' Week is especially imperative.

2. We must consider at once the necessity of limiting registration, especially in the ten weeks' courses, or else providing additional instructors in several departments in order to give satisfactory instruction. Since there are large numbers of mature people in the State who want this kind of work, and through the short courses the college has the opportunity to render a distinct service to them, it would be rather unfortunate to deprive these persons of the chance to enroll.

3. The time has come when we should consider the question of enlarging and extending the short courses to cover a period of two and possibly three winters. Those who enter these courses are of various ages, training, and experience. Many are graduates of the best universities of the country; others have had scarcely a grammar school training. It is extremely hard to teach such a cosmopolitan group. This plan would involve considerable addition to the teaching force and laboratory equipment, but would be well worth considering.

4. The directors of county schools of agriculture and the teachers of agriculture in vocational schools have made the request that the college take the students from the last year in these schools into our short courses for special training in dairying, fruit growing, and other subjects. This seems a very natural and proper thing to do, and furnishes the desired articulation between these schools and the college. In four or five years such students will be coming to us in large numbers. If a sufficient teaching force and laboratory equipment are not furnished here at the college, each county school and many towns will be forced to spend large sums of money to equip dairy plants and other branches. It seems to the supervisor that for many reasons every effort should be made to take care of these students.

5. A faculty committee on appointments, to take care of applications for farm superintendents and others, would be most helpful in placing short-course students in desirable positions.

The short courses, reaching as they do more than 3,000 earnest people each year, are well worthy of more careful study, planning and more financial support than we have been giving them during recent years.

WILLIAM D. HURD,
Supervisor of Short Courses.

DIRECTOR OF THE EXPERIMENT STATION.

Staff.

The experiment station has been fortunate in experiencing but very few changes in staff during the year, and those affecting only one or two minor positions. The staff has been distinctly strengthened by the appointment of Mr. Orton L. Clark to a position in the Department of Plant Physiology and Pathology.

Publication.

The law affecting publication of the reports and results of station work has been amended during the past year. The amended law brings the method of publication into conformity with that recommended by the Association of American Agricultural Colleges and Experiment Stations, and at the same time the new method secures a number of other important advantages: —

1. Results are published promptly in bulletin form instead of being held until the end of the year.

2. As each bulletin is bound by itself it can be circulated with greater economy, being sent only to those especially interested in the subject-matter.

3. The new method avoids sending reports and bulletins in duplicate to individuals whose names are included in the mailing lists both of the station and the State Board of Agriculture, as must frequently have been done under the old law.

4. Under the new law the cost of publication of bulletins is borne by the State instead of being provided for from the general funds of the station.

5. While securing all these advantages and relieving station funds, as indicated under paragraph 4, the cost to the State is materially lessened under the new plan of publication. The saving during the past year has amounted to about $1,000.

Bulletins.

Eight bulletins have been issued during the year, as follows: —

No. 148. Diagnosis of Infection with *Bacterium Pullorum* (white diarrhœa) in the Domestic Fowl.

No. 149. A Study of Variation in Apples.

No. 150. Reports on Experimental Work in Connection with Cranberries.

No. 151. The Determination of Acetyl Number (Fat Analysis).
No. 152. The Digestibility of Cattle Foods.
No. 153. A Summary of Meteorological Records.
No. 154. Alfalfa.
No. 155. New Fertilizer Materials and By-products.

The meteorological summary covers twenty-five years of our own observations, and in addition includes observations on temperature and rainfall from 1836 to 1888 (when observations at this station began), which were begun by the late Professor Snell of Amherst College and continued by his daughters. The records thus brought together cover so long a period of time as to make them of very great value for purposes of reference and comparison.

The bulletin on diagnosis of white diarrhœa describes a method whereby fowls which will produce eggs that will hatch into chickens which will become subject to the disease can be detected by a simple test and removed from the flock. The practical test of the method shows it to be, practically speaking, infallible, and in one flock in which it has been tried upon an extensive scale, where losses previous to the introduction of the test included about 2,000 chickens, the loss was reduced to practically nothing.

The bulletin on alfalfa presents a concise account of our long-continued experiments with this crop, and based upon the discussion of these results, conclusions and advice of much practical importance are presented.

The annual bulletin on cranberry work is eagerly looked forward to by practically all growers, who show the keenest interest in the conclusions of Dr. Franklin, and recognize the great value of advice based upon the results of his investigations.

Station Plots.

During the past year a considerable number of station plots have been taken as sites for buildings, thus greatly reducing our possibilities in a number of important lines of investigation. Closely connected with this should be mentioned the increasing difficulty of avoiding trespass on other plots, due to the tendency of students to take direct lines in passing from building to building.

Extension Work.

The station is still doing a large amount of work which really belongs to the extension service. Every department calls attention to the large number of letters of advice required. In addition, a large amount of time is consumed in diagnosing the causes of injury to crops and the diseases of animals. Work of this kind is highly appreciated and should be continued, but attention is called to the fact that much of it is not investigational in character.

Seed Separation and Examination.

The demands for work of this character have increased materially, and it requires a large amount of time. It is useful work, but is more or less routine in its character, and, except in so far as may be necessary for the purpose of inventing or perfecting methods, is foreign to the work of an experiment station. Seedsmen in increasing numbers are sending large amounts of seeds to the station to be freed from impurities and separated into different grades. This work is clearly outside the province of the experiment station and a change in policy is imperative.

Pressing Needs.

The most immediate pressing need of the experiment station is more land. I believe that on this point all departments, even those not depending very directly upon the use of land, are in full agreement. The reasons why more land is essential are in part indicated by my statement of what has happened to a number of station plots during the past year. I have made so full a statement of the reasons why more land is needed in the experiment station in my last annual report that I beg leave to refer to my discussion of the land question in that report, which begins on page 11*a*.

Other special considerations affecting the question of the need of more land are connected with the continuance and development of the work of the Poultry Department. A considerable area to provide for the permanent accommodation of the poultry plant should be secured in the near future, but Professor Graham urges the necessity for the immediate provision of some

three or four acres. He regards this as absolutely essential on account of the fact that the land now occupied is infected with serious diseases which cannot be entirely held in check under existing conditions.

The Poultry Department strongly urges the provision at as early a day as possible of a poultry house in which the environmental conditions can be controlled, this house to be used in the principal line of investigation now in progress. Dr. Goodale points out that the variation in the character of the weather of different years is so great that rigid scientific deductions are impossible when laying fowls are kept in houses of ordinary construction. He points out that satisfactory comparisons between parents and their offspring in successive years are impossible unless conditions be controlled. Since additional room to accommodate the experimental work is an immediate necessity, it would seem to be the part of wisdom to ask for an appropriation sufficiently large to build a house of the character indicated.

In the Department of Meteorology there are two needs which should be met as soon as practicable: —

1. The provision of an automatic rain gauge to insure greater accuracy in the records of precipitation, especially in winter.

2. A safe to contain the records of the department.

Additional Assistants.

Both the Poultry and the Veterinary departments urge the desirability of an additional assistant. Professor Graham believes he should have a man capable of diagnosing and studying poultry diseases, and if he has such a man he must have also a laboratory and laboratory equipment for pathological work. A considerable share of the time of such a man would be used in examining diseased specimens and answering letters of inquiry pertaining to diseases and their treatment sent to the department.

Dr. Paige of the Veterinary Department strongly urges the desirability of a man qualified to do similar work on live-stock diseases in general. He mentions particularly that there is a demand for the complement fixation test for the diagnosis of contagious abortion in cattle — a demand which cannot be met under present conditions. There can be no doubt that great

service could be rendered to the dairy men of the State if this diagnostic work could be carried out here, as it would constitute a most effective preliminary to the eradication of contagious abortion, now the occasion of enormous annual loss, from our dairy herds. Dr. Paige believes that such an assistant would be able, also, to continue such work as Dr. Gage has carried out on the premises of one of our largest poultry keepers for the diagnosis and consequent prevention of white diarrhœa of fowls — also the occasion of immense annual loss. Dr. Paige believes that such a man would be able to do the work needed in the Poultry Department, and in this belief I concur. I would urge the employment as soon as possible of a single qualified man for the lines of work just mentioned, and such others related to them as his time will allow. It seems to me clear that all work connected with animal pathology should be done in one department, and that the department best fitted to handle it is the Veterinary Department. The employment of a single man rather than two is in line with the policy of maintaining departmental integrity. It is also the course dictated by considerations of business efficiency and economy. The necessary laboratory and equipment for pathological work are found in the Veterinary Department. No considerable additional investment will be required for the additional work in that department, whereas if a pathologist for work in the Poultry Department is to be employed there must be a large expenditure for laboratory and equipment. Dr. Paige suggests that a graduate student might be able to do the class of work under consideration, and I would urge the employment of such a man as soon as a suitable person can be found.

I would, however, in this connection point out that the services to be rendered by such a man are in very considerable measure of the nature of extension rather than experiment, and it would seem to me that the salary of such an assistant should be divided between the extension service and the experiment station.

Plant Pathologist.

Dr. Stone and Professor Osmun concur in thinking that an assistant should be employed, especially for diagnostic work in the Department of Plant Physiology and Pathology. There

is a large number of specimens annually sent in to the department. The examination of these, and the diagnosis of the cause of the trouble complained of, require a large expenditure of time, and in many cases a satisfactory explanation of the cause of the trouble, and advice relative to its prevention or cure, cannot be given until an examination on the spot has been made. It is not practicable for either of the assistants now employed to make the necessary trips and spend the amount of time desirable for this line of work, and the best way of providing for it would seem to be the employment of a careful and reliable observer, who should make the necessary trips, investigate conditions, and collect and send material for examination to the department. There is a somewhat insistent demand on the part especially of market gardeners, and those employed in the production of hothouse specialties, that a substation to work in their interests should be established. The establishment of such a station and its maintenance would require the expenditure of relatively large sums of money. The equipment essential for diagnostic work now exists in the department. To duplicate it at another station seems quite unnecessary, as diseased material can readily be sent to the home station. It seems, therefore, that a man, who should spend a considerable share of his time during the growing season of our great truck and hothouse specialties among the growers, going wherever trouble was being experienced to investigate conditions and collect and forward material, would be by far the most economical and at the same time effective means of meeting the needs of the important classes of agricultural specialists referred to. I would, therefore, urge that a man qualified for this kind of work be employed as early as possible.

Salaries.

Another pressing need is that the salaries of the experiment station staff shall be carefully correlated with those of members of the college staff in other divisions and departments. The salaries in the station are at present in many cases below the institutional standard. It is felt that this condition, which is of course highly unsatisfactory, should be corrected before the scope of the station investigations should be greatly extended.

It further seems highly important that the basis for division of salaries between the station and other departments of the institution should be readjusted to more nearly conform to that of time spent on the part of individuals working in more than one department.

William P. Brooks,
Director.

DIRECTOR OF THE EXTENSION SERVICE.

In attempting to render an adequate report of the work of the extension service one faces a discouraging task. A written report may cover bare facts and give statistics, but the spirit which permeates all true extension teaching cannot be represented in a report of this kind. In this connection I desire to commend especially all members of the extension service staff, and many members of the teaching and experimental staffs of the college and station, for their loyalty to and enthusiasm for the work, and for the genuine interest which they have shown in attempting to make themselves and their work helpful to the rural interests of the Commonwealth.

A. General Administration.

1. *Principal Lines of Endeavor for the Year.*

The administration of the extension work of the college during the past year has been directed along the following lines: (*a*) an attempt to perfect the organization of an extension service within the college itself, which would be efficient and work harmoniously in the already established plan of organization; (*b*) the further organization of work already under way rather than the starting of new lines of work; (*c*) the consummation of the plan proposed about three years ago for co-operative work between the State Board of Education, through county schools of agriculture and departments of agriculture in high schools, the United States Department of Agriculture, and the college; (*d*) an effort to get farm bureaus and the work of county agents organized in this State on the same plan as has been adopted in other States; (*e*) working out plans for satisfactory relationships between the United States Department of

Agriculture and the college in the expenditure of co-operative demonstration funds; (*f*) the working out of plans for the administration of the Lever bill funds, so that they would be of greatest benefit to the State and would meet with the approval of the authorities at Washington.

2. *Changes in Staff and Additions.*

Fortunately for the work there have been no resignations or changes in the staff during the past year.

3. *Printing and Publications.*

During the year bulletins and circulars of each of the short-course activities have been published. Thirteen numbers of "Facts for Farmers" have been issued. Several have gone into reprints for wider distribution by different organizations. Twenty thousand extra copies of "Redirection of the Rural School" were printed for the United States Bureau of Education. The North Packing Company printed 20,000 of our bulletins on "Swine Feeding" for distribution. For use in the boys' and girls' club work a general bulletin and five primers have been issued. Besides the above there have been large numbers of record blanks, library leaflets, announcement cards, etc. News letters have been sent to the press weekly.

4. *Correspondence Courses.*

The correspondence courses have been reorganized during the year. There has been a total registration of 1,059. New courses in home economics and rural sociology have been offered. The courses in soils, fertilizers, dairying, feeding, and fruit growing have been rewritten. Better "follow-up" and instructional methods are being practiced.

5. *Itinerant Instruction.*

(*a*) *Extension Schools.* — The extension schools continue to be the best things offered away from the college. Ten agricultural extension schools, two in community development, and one special school in fruit growing have been held during the year.

(*b*) *Lectures.* — More than the usual number of lectures have been given by the college faculty this year. Four towns adopted the plan of having courses. At the present time a course of forty-five lectures is being given under the auspices of the Boston Chamber of Commerce, with an enrollment of more than 900. A course in gardening and club work is being given for the Boston Board of Education to 75 picked leaders from the different districts of that city. The college, the Federation of Women's Clubs, and the grange have co-operated in offering a free course of five lectures on home economics during the coming winter to all small communities that desire it.

(*c*) *Exhibits.* — Educational exhibits, supplemented by lectures and demonstrations, have been made at ten fairs. Two special exhibits were provided for other organizations.

6. *The Massachusetts Agricultural College Agricultural Improvement Association.*

The work of this association has continued along the lines of corn, potato, and pasture improvement. One session during Farmers' Week was under the auspices of this organization. The membership now numbers over 250.

7. *Demonstration Auto Truck.*

The demonstration auto truck, with Mr. McDougall as the very efficient demonstrator in charge, continues to be perhaps our best means of getting into intimate touch with farmers. During the year he has given 77 demonstrations, has made 418 farm visits, and spent from two days to a week in each of 68 towns. Mr. McDougall spent three months during the winter assisting in pomology and farm management work.

8. *Home Economics.*

As might have been expected when this work for women was started, those in charge have been in much demand by various organizations in the State. A large number of lectures and demonstrations have been given. Work for women of the same extent as for men has been given in all extension schools. One separate extension school on homemaking has been held in

Woods Hole. Girls' home economics clubs and a correspondence course have been started. The co-operation of the Federation of Women's Clubs and the grange has been enlisted in an effort to give a course of five lectures in a large number of small towns under our management during the coming year.

9. *Farm Bureaus and County Agents.*

(*a*) *Hampden County.* — The extension service has continued its active relationships in the management of the work of the Hampden County Improvement League during the year. Much progress has been made, under the instruction of advisers of the league, in better cropping systems, dairy and orchard management, buying (coöperatively) lime, fertilizers, feeds and apple barrels, selling fruit, and in the development of work for young people within the county.

(*b*) *Worcester County.* — A farm bureau was organized in this county in March, 1914, but was inactive until November 10, when Charles H. White (Massachusetts Agricultural College, 1909) was engaged as its agent. He is just entering on his duties, and is depending on the college largely for direction of the work.

(*c*) *Other Counties.* — Franklin and Hampshire counties have already organized farm bureaus, but have not as yet engaged county agents. Plymouth is in process of organization, and others have the matter under consideration.

10. *Demonstration Farms.*

(*a*) *Barnstable County.* — The Faunce Demonstration Farm at Sandwich continues to be a matter of inspiration, and serves as the center for the dissemination of agricultural information for the people of that region. A plot of ground of less than 8 acres has yielded more than $1,600 worth of poultry, small fruits, and vegetables during the year. Mr. L. B. Boston, the superintendent, spends a goodly portion of his time as adviser to farmers and district agent for the college.

(*b*) *The Paige Farm.* — The Paige Demonstration Farm at Hardwick is now under the advisory direction of the college. Mr. Robert D. Lull (Massachusetts Agricultural College, 1911), the superintendent, is proving a very efficient leader in the com-

munity, and besides managing the farm and the farmers' exchange, is also active in the program of work for community development started in the town two years ago.

11. *Co-operative Work.*

(*a*) *The United States Department of Agriculture.* — The college now has with the United States Department of Agriculture a general memorandum of understanding under which all the work of the department within the State is to be done. Under this memorandum the director of the extension service becomes the State leader for the United States Department of Agriculture, and arranges and directs the work. At the present time the United States Department of Agriculture is co-operating in helping to pay the salaries and expenses of Prof. O. A. Morton and Miss Nash in boys' and girls' club work, Professor Ferguson for milk distribution work, Mr. Baker and Mr. Ellis for farm management studies, an appropriation of $1,200 for county work in each of two counties, all of the salary and expenses of Dr. D. I. Skidmore in hog cholera demonstrations, also co-operating in some pasture demonstration work, and giving some money for supervision and "follow-up" work in tabulating farm records, and boys' and girls' club work.

(*b*) *State Board of Education.* — The plans considered for the past three years of having teachers of agriculture in vocational schools and county schools of agriculture work under the direction of the college in so far as they deal with adult farmers has been consummated during the year. Co-operative agreements now exist between the Board of Education, the United States Department of Agriculture, and the college. Thirteen teachers in vocational schools, and representatives in the two county schools of agriculture and the Smith's Agricultural School, now act as extension representatives. This plan insures the same types of extension teachings and demonstrations being carried on all over the State, and looks toward economy, efficiency, and harmony in our administration. A special school of instruction for these men, lasting one week, was held at the college last February, and they also attended the summer conference.

(*c*) *Other Organizations within the State.* — The extension service has continued its policy of attempting to utilize existing

organizations within the State for its work rather than the creation of new machinery. Organized pieces of work have been carried out with the State Board of Agriculture, the Grange, the State Board of Health, the Massachusetts Civic League, the State Forester, the Federation of Women's Clubs, the Board of Education, the New England Home Economics Association, the Massachusetts Forestry Association, the fairs of the State, the Federation of Churches, city and county Y. M. C. A.'s, boards of trade, and many local and town organizations.

12. *The Smith-Lever Bill.*

In May, 1914, Congress passed the Smith-Lever bill, giving an initial appropriation of $10,000 to the State for demonstration work in agriculture and home economics. Plans were at once made to receive the benefits of the appropriation. Projects were submitted to Washington and were approved. At the present time these funds are being applied toward the support of demonstration work already started in fruit growing, animal husbandry, boys' and girls' clubs, dairying, demonstration auto truck, home economics, farm management, and the printing of practical bulletins and leaflets.

B. Extension Work through Departments and Extension Specialists.

1. *Pomology.*

At the present time we have nineteen demonstration orchards in different sections of the State. One extension school in fruit growing was held during the year. A large number of single lectures, demonstrations, and farm visits were given and assistance was rendered at fruit shows, fairs, etc.

2. *Animal Husbandry.*

During the year Mr. George F. Story was transferred from the Dairy to the Animal Husbandry Department. The organization of Dairy Improvement and Breeding Associations has been encouraged. The Fall River milk campaign, started three years ago, has been continued. Fourteen stock-judging contests for boys have been held in which 234 participated. The usual number of lectures and demonstrations have been given.

3. *Boys' and Girls' Club Work.*

Of all lines of work this is no doubt the most far-reaching and significant. More than 42,000 boys and girls have been enrolled during the year. Clubs have been organized in over 250 towns. The work now covers corn, potatoes, gardening, home economics, poultry, and canning. Six boys and one girl made the trip to Washington. Seven of the winners in potato contests took the trip to Aroostook County, Me. Three spent a week at our Boys' Camp. The sum of $2,000 in extra prize money is now given through the State Board of Agriculture for this work. The club work connects the school and the home in a better manner than I have ever known before. In this work we have the active co-operation of a large majority of school superintendents, teachers, and fair managers of the State. Requests have been made for us to organize fruit, pig, and calf clubs. We do not deem it wise to enlarge the work until more supervision can be given. Fully 100,000 boys and girls in the State would enroll if we could furnish the necessary supervision and follow up the work.

4. *Farm Management.*

The work of farm management field studies and demonstrations, in order to determine what are profitable systems for farmers to follow, has been continued during the year. Partial surveys of from 10 to 60 farms have been made in a large number of towns. About 100 demonstration plots, covering fertilizers, grass products, and alfalfa, have been carried on. Plans are under way to carry on complete surveys and annual follow-up work on about 60 farms in each of 8 communities during the coming year. This work is reaching down to fundamental problems with which farmers have to deal, and in time will prove one of our most valuable lines of work.

5. *Poultry Extension Work.*

Professor Graham has given a large number of lectures and demonstrations along poultry lines, and has assisted in the organization of several poultry associations during the year. Blue-print plans of poultry houses and appliances have been

freely loaned. Boys' poultry club work and a correspondence course have been started. The poultry convention brought 700 or 800 people to the college. There is an urgent need of adding several extension instructors and demonstrators for work all over the State in combating diseases, planning poultry houses, and on problems of incubation, brooding, mating, feeding, and general care.

6. *Civic Improvement.*

In this line of extension work studies have been made in 20 towns. Plans in many cases have been drawn for improving the commons, the church, school, cemetery, or home grounds. Complete plans have been furnished Sterling for a comprehensive scheme of town development, including parks, recreational centers, etc. A special exhibit of this kind of work was held in the Amherst town hall last April, and a plan for the laying out of a town has been sent to the Chicago exhibition and competition.

7. *Community Service.*

Calls have continued to come in for help along community development lines. Definite long-term projects have been laid out and adopted in 13 towns. Two extension schools covering these subjects have been held during the year. Professor Morgan has attended a large number of conferences and meetings which will no doubt lead several other communities to take up the work later. A detailed study of what has actually been accomplished by such a program of work in the town of Hardwick shows the possibilities of well-directed effort in this direction. Professor Morgan has also rendered valuable service as secretary of the Massachusetts Federation of Rural Progress.

8. *Library Extension Work.*

The college librarian has further developed the plan of sending traveling libraries and selected lots of books to the smaller libraries of the State. About 700 volumes are now available for this work. There have been 760 books and 240 pamphlets loaned to 42 libraries during the year. Eight special library leaflets have been printed and distributed.

9. *Extension Work in Dairying.*

Lectures and demonstrations have been given on the subjects of handling and marketing milk. Three of the largest milk shows ever held in the country have been arranged during the year. Clean milk exhibits have been held in cities. In this work fine co-operation has prevailed between the college, the Massachusetts Dairy Men's Association, and the milk inspectors of the State.

10. *Co-operation and Marketing.*

During the year the work of assisting in the organization of farmers' co-operative business organizations and in marketing has been started. Co-operative organizations have been formed in 7 towns. Assistance in starting credit unions has been given to 7 towns, and 16 other towns have been visited and conferences held regarding the work. Professor Ferguson has spent approximately one-half of his time in a study of the methods of milk distribution in typical small and medium-sized towns, and in cities for the Office of Markets at Washington. Definite data have been secured which will later be used in an effort to help solve the ever-present, and at the present time decidedly unsatisfactory, situation in which the dairy industry finds itself in this State.

11. *Extension Work in Prevention of Hog Cholera.*

Dr. D. I. Skidmore was assigned last July to the State by the United States Bureau of Animal Industry, for demonstration work in the prevention of hog cholera. A careful watch is being kept for the disease, and when found Dr. Skidmore shows proper sanitary measures necessary for its eradication. Demonstrations of the application of the serum treatment to live hogs, and talks on the subject, have been given at all of the larger fairs of the State and at special meetings. During the year Dr. Skidmore will work with the 29 State institutions that have considerable trouble with the disease, and through county agents, vocational instructors, granges, and other organizations, in an effort to institute a campaign which will practically eradicate the disease from the State.

C. Plans for the Work and Needs of the Coming Year.

1. With an appropriation already fixed for the next three years by the State, and the fact that, due to the reasons already stated, Massachusetts receives but $2,440 additional each year from Smith-Lever bill funds, no enlargement or expansion of extension activities can be expected. The most that we should try to do is to retain if possible our present excellent force of extension workers, and to perfect within the institution itself a better working organization. The idea that live virile instruction like extension work can stand still is one of the greatest fallacies ever agreed to by the trustees.

2. There is an urgent need of the trustees adopting a definite policy defining what the extension work of a State institution should be, and the relation of all employees of the college to it. The idea is all too prevalent that the extension service is simply a department of the college. The director suggests that the following definition might be used on which to base the policy: "The extension service is the whole institution (every department and individual) at work doing what it can to upbuild the rural life of the Commonwealth, and all employees are expected, in so far as extension work does not interfere with their teaching or research work, to take their part in this movement, and to make themselves and their departments as useful as is possible in the different movements to build up the agricultural industry of the State." The director further suggests that if this is to be the policy of the institution then at least the attitude toward extension work in general of all persons taken on to the staff of the college or station should be considered as well as their other qualifications.

3. While there is probably no chance of our meeting any of the immediate needs for more help, yet these should nevertheless be presented. There are organizations such as the poultry men, and those interested in boys' and girls' club work, and market gardening, who are willing to go before the Legislature and secure funds to carry on the work which they want. It seems to me that under such circumstances no objection should be raised by the college.

The most urgent needs are as follows: —

(*a*) Extension instruction in market gardening (organized on same plan as county work): —		
College's share of salary,	$2,000	
Community pay salary,	1,000	
Travel and transportation,	700	
Office expenses,	1,000	
	$4,700	$2,000[1]
(*b*) Extension work in poultry husbandry: —		
Two demonstrators' salaries,	$3,000	
Traveling expenses,	1,000	
Equipment, etc.,	500	
	$4,500	4,500
(*c*) For salaries and travel of supervisors of boys' and girls' clubs (college pays one-half and United States Department of Agriculture pays one-half),	$6,000	3,000[1]
(*d*) Extension work in agronomy: —		
Salary,	$1,500	
Travel,	500	
Equipment,	200	
	$2,200	2,200
(*e*) Adviser for work with State institutions (asked for by them; recommended by Governor): —		
Salary,	$3,000	
Travel and other expenses,	1,000	
	$4,000	4,000
(*f*) Extension work in fruit growing: —		
Salary,	$1,500	
Travel,	500	
Equipment,	200	
	$2,200	2,200
(*g*) For co-operative work with United States Department of Agriculture: (1) farm management; (2) demonstrations; (3) boys' poultry and fruit clubs (college pays one-half and United States Department of Agriculture pays one-half),	$6,000	3,000[1]
(*h*) Pay toward the salary of each extension representative in vocational schools and county agricultural schools, $100,		1,800
Total,		$22,700

[1] College share.

4. Since the college receives for instructional purposes an automatic increase in its funds, the cost of running the short courses (approximately $8,000) might be paid from these funds, thus relieving the extension budget to that extent; then some of this much-needed work could be started.

5. Every effort is being made to develop within the college an extension organization which is in line with that advocated by the leaders of the movement in the several States and in the United States Department of Agriculture. It is expected that a good deal of progress can be made during the coming year.

6. Plans have been made to have projects presented soon after December 1 by every man expending Extension Service money, in order that the work may be carefully reviewed at the beginning of the year and checked up at the end.

7. I would recommend that a complete report of the extension service covering the work of the last two years be printed as near January 1 as is possible.

William D. Hurd,
Director.

TABLES AND STATISTICS.

Table I. — *New Appointments.*

In the Academic Departments.

Position.	Name.	Institution from which graduated and Degrees.
Graduate assistant in microbiology, .	Roy C. Avery, . .	Connecticut Agricultural College, B.Sc., 1914.
Assistant in dairying, ...	Harold E. Baldinger,	Cornell University, B.Sc., 1914.
Associate professor of rural engineering,	Christian I. Gunness,	North Dakota Agricultural College, B.Sc., 1907.
Graduate assistant in chemistry, . .	Franklin C. Gurley, .	Worcester Polytechnic Institute, B.Sc., 1914.
Instructor in dairying, ...	Ivan McKellip, . .	Nebraska State University, B.Sc.Agr., 1911. Cornell University, M.Sc. Agr., 1912.
Graduate assistant in agronomy, . .	Frederick G. Merkle,	Massachusetts Agricultural College, B.Sc., 1914.
Graduate assistant in chemistry, . .	Stuart P. Miller, .	Worcester Polytechnic Institute, B.Sc., 1914.
Assistant professor of floriculture, .	Arno H. Nehrling, .	Missouri Botanical Garden and Shaw School of Botany, F.H.S., 1909.
Graduate assistant in landscape gardening.	Carl F. Oberhelman, .	Ohio State University, B.Sc., 1913.
Instructor in poultry husbandry, .	Loyal F. Payne, .	Oklahoma Agricultural College, B.Sc., 1912.
Instructor in English, ...	Frank P. Rand, .	Williams College, A.B., 1912.
Assistant in entomology, . . .	William S. Regan, .	Massachusetts Agricultural College, B.Sc., 1908.
Graduate assistant in floriculture, .	Arthur S. Thurston, .	Massachusetts Agricultural College, B.Sc., 1914.
Graduate assistant in animal husbandry,	Warren F. Whittier, .	Harvard College, A.B., 1909.

In the Experiment Station.

Position.	Name.	Institution from which graduated and Degrees.
Assistant botanist,	Orton L. Clark,	Massachusetts Agricultural College, B.Sc., 1908.

In the Extension Service.

Extension instructor in farm demonstration.	Benjamin W. Ellis,	Massachusetts Agricultural College, B.Sc., 1913.
Extension professor of agricultural economics.	Richard H. Ferguson,	Ontario Agricultural College, B.Sc.Agr., 1913.
Extension instructor in home economics.	Harriet J. Hopkins,	Teachers College, Columbia University, B.Sc., 1914.
Extension instructor in agricultural education.	Ethel H. Nash,	Hyannis State Normal School, 1907.

In the Clerical Staff.

Position.	Name.
Clerk, Department of Farm Administration,	Frances E. Boynton.
Clerk, president's office,	Mary E. Horton.
Stenographer, Department of Poultry Husbandry,	Elizabeth E. Mooney.
Stenographer, treasurer's office,	Gladys P. Moore.
Clerk, treasurer's office,	Luther R. Putney.
Stenographer, Division of Horticulture,	Helen C. Pomeroy.
Bookkeeper, treasurer's office,	Edna M. Sanders.
Stenographer, extension service,	Elsa Slattery.
Stenographer, Department of Agricultural Economics,	Harriet C. Stevenson.
Stenographer, Division of Agriculture,	Aurelia B. Wentworth.

Table II. — *Resignations.*

Position.	Name.
Clerk, Division of Agriculture,	Luliona M. Barker.
Instructor in poultry husbandry,	Adrian A. Brown.
Cashier,	Harold A. Crane.
Associate professor of rural sociology,	Elmer K. Eyerly.
First clerk, experiment station, Department of Chemistry,	F. Ethel Felton.
Instructor in market gardening,	Bert C. Georgia.[1]
Assistant botanist, experiment station,	Edward A. Larrabee.
Instructor in dairying,	Ivan McKellip.
Dean emeritus,	George F. Mills.[2]
Stenographer, treasurer's office,	Gladys P. Moore.
Stenographer, treasurer's office,	Dorothy Mudge.
Foreman, poultry experimental yards,	John W. Sayer.

[1] Died May 24, 1914.

[2] Died Oct. 27, 1914.

TABLE III. — *Change in Title of Officers of the Institution.*

Name.	Former Title.	Present Title.
Ernest Anderson,	Assistant professor of chemistry,	Associate professor of chemistry.
Robert H. Bogue,	Assistant in chemistry,	Instructor in chemistry.
Mary E. Caldwell,	First clerk, treasurer's office,	Cashier.
C. Robert Duncan,	Instructor in mathematics,	Assistant professor of mathematics.
Burton N. Gates,	Assistant professor of beekeeping.	Associate professor of beekeeping.
Lillian M. Gelinas,	Stenographer, president's office,	Clerk, president's office.
Cora B. Grover,	Stenographer, extension service,	Clerk, extension service.
Helena T. Goessmann,	Assistant in English,	Instructor in English.
Curry S. Hicks,	Assistant professor of physical education and hygiene.	Associate professor of physical education and hygiene.
Alice M. Howard,	Clerk, experiment station,	First clerk, experiment station.
Edward M. Lewis,	Associate dean of the college and professor of literature.	Dean of the college and professor of languages and literature.
F. A. McLaughlin,	Assistant in botany,	Instructor in botany.
William L. Machmer,	Instructor in mathematics,	Assistant professor of mathematics.
George F. Mills,	Dean of the college,	Dean emeritus.
Arno H. Nehrling,	Assistant professor of floriculture.	Associate professor of floriculture.
A. Vincent Osmun,	Assistant professor of botany,	Associate professor of botany.
Elvin L. Quaife,	Instructor in animal husbandry,	Assistant professor of animal husbandry.
F. H. VanSuchtelen,	Assistant professor of microbiology.	Associate professor of microbiology.
Ralph J. Watts,	Secretary to the president,	Secretary of the college.
Henrietta Webster,	Bookkeeper, treasurer's office,	First clerk, treasurer's office.

TABLE IV. — *Speakers for the Year.*

A. Speakers at Wednesday Assembly for Year ending Nov. 30, 1914.

1913.

Dec. 10. — Hon. Frank H. Pope, Boston, "Persistency of Opportunity."
Dec. 17. — Dr. Charles Fleischer, Boston, "Democracy."

1914.

Jan. 21. — Dr. William Burdick, Baltimore, Md., "Loyalty and College Athletics."
Feb. 11. — Mr. William H. Lewis, Boston, "Race and Democracy."
Feb. 18. — Mr. Sydney H. Coleman, Albany, N. Y., "The American Humane Association."
Feb. 25. — Prof. Paul C. Phillips, Amherst College, "The Olympic Games at Stockholm."
Mar. 4. — Dr. Shosuke Sato, Japan, "Japan."
Mar. 11. — Mr. Albert D. Taylor, Boston, "Personal Experience in Business."
Mar. 18. — Rev. E. B. Robinson, Holyoke, Mass., "Becoming a Neighbor."
Mar. 25. — Prof. Kenneth McKenzie, Yale University.
Apr. 15. — Mr. Wilfrid Wheeler, Boston, "The Work of the State Board of Agriculture."
Apr. 22. — Mr. Ora S. Gray, Amherst, "The Animals of Ephesus."
May 13. — Pres. Kenyon L. Butterfield, "The Southwest."
May 20. — Mr. John A. Scheuerle, Springfield, Mass., "The Work of the Hampden County Improvement League."
May 27. — Mr. Henry Lasker, Springfield, Mass., "Patriotism in Times of War and of Peace."
Sept. 16. — Prof. Robert J. Sprague, M. A. C., "The Roots of the War."
Sept. 23. — Pres. E. T. Fairchild, New Hampshire State College, "Success and Failure."
Sept. 30. — Prof. Frank A. Waugh, M. A. C., "Civic Art."
Oct. 7. — Pres. Kenyon L. Butterfield, "The College as a Leader."

Oct. 14. — Prof. John M. Tyler, Amherst College, "Leadership."
Oct. 21. — Dr. Edwin D. Mead, Boston, "The United States and the United World."
Oct. 28. — Dr. Henry Wallace, Des Moines, Ia., "Leadership."
Nov. 4. — Pres. Kenyon L. Butterfield, "The College Man as a Leader."
Nov. 11. — Prof. Lewis Perry, Phillips Exeter Academy, "Education and the Drama."
Nov. 18. — Mr. W J. Campbell, Springfield Y. M. C. A. College, "The Work of the County Secretary of the Y. M. C. A."

B. Speakers at Sunday Chapel for Year ending Nov. 30, 1914.

1913.

Dec. 7. — Rev. R. H. M. Augustine, Hanover, N. J., "Three Essential Elements in the New Rural Civilization."
Dec. 14. — Rev. Samuel A. Eliot, Boston, "The Uses of Adversity."

1914.

Jan. 11. — Mr. Albert E. Roberts, New York City, "The Cost of Leadership."
Jan. 18. — Dr. Charles R. Brown, Yale University, "The Man and Inner Man."
Feb. 8. — Dr. Albert P. Fitch, Cambridge, Mass., "Three Marks of Genius in Youth."
Feb. 15. — Rev. Theodore Sedgwick, New York City, "Who Hath Warned You?"
Mar. 1. — Rev. Herbert J. White, Hartford, Conn., "The Salvation of a Christian."
Mar. 8. — Rev. Anson P. Stokes, Yale University, "Christianity."
Mar. 15. — Prof. John E. Russell, Williams College, "How to make Life Worth Living."
Mar. 22. — Rev. Paul R. Frothingham, Boston, "The Significance of Tools."
Apr. 12. — Rev. Willard Scott, Brookline, Mass., "The Excelling Life."
Apr. 26. — Rev. Nehemiah Boynton, Brooklyn, N. Y., "Prosperity — An Affair of Spirit."
Sept. 13. — Pres. Kenyon L. Butterfield, "Character Building."
Nov. 8. — Mr. Albert E. Roberts, New York City, "The Abundant Life."
Nov. 15. — Rev. E. B. Robinson, Holyoke, Mass., "The Unsuspected Purpose of God."
Nov. 22. — Rev. Clarence F. Swift, Fall River, Mass., "The Cord of Blue."

Table V. — *Attendance.*

A. In Work of College Grade.

	Registration Nov. 30, 1913.	Registration Nov. 30, 1914.
Senior class,	98	103
Junior class,	103	113
Sophomore class,	140	142
Freshman class,	201	168
	542	526
Graduate students,	39	52
Unclassified students,	24	32
Total doing work of college grade,	605	610

B. Short-course Enrollment and Convention Registration.

	1913.	1914.
Winter school,	153	182
Summer school,	133	146
Apple-packing school,	25	30
School for tree wardens,	44	22
Beekeepers' school,	6	–
Farmers' Week,	950	1,563
School for rural social service,	–	22
Boys' Camps,	33	47
Polish farmers' day,	–	86
Poultry convention,	362	586
Conference on rural community planning,	247	329
Beekeepers' convention,	115	–
Convention of county agents and agricultural instructors,	–	28
Total,	2,068	3,041

TABLE VI. — *Legislative Budget, 1914.*

Items.	Amount asked.	Amount granted.
Special appropriations: —		
Agricultural building, including equipment,	$210,000	$210,000
Student dormitory,	35,000	–
Minor additions,	10,000	–
	$255,000	$210,000

TABLE VII. — *Statistics of Freshmen entering Massachusetts Agricultural College, September, 1914.*

A. Home Addresses of Students (classified by Towns and Cities).

Adams,	1	Hartford, Conn.,	1	Paterson, N. J.,	3
Amesbury,	1	Haverhill,	1	Peabody,	3
Amherst,	6	Hingham,	3	Pittsfield,	2
Andover,	1	Holyoke,	4	Plainfield, N. J.,	1
Arlington,	1	Hopkinton,	1	Plainville, Conn.,	1
Ashfield,	1	Hyde Park,	2	Plymouth,	1
Attleborough,	1	Ipswich,	1	Putnam, Conn.,	1
Ayer,	1	Keene, N. H.,	1	Quincy,	1
Barre,	1	Kinderhook, N. Y.,	1	Revere,	2
Bedford,	1	Lawrence,	2	Rockland,	1
Belchertown,	1	Lima, N. Y.,	1	Salem,	4
Berlin,	1	Lowell,	1	Scitio, Conn.,	1
Beverly,	2	Lynn,	5	Sharon,	2
Blackstone,	1	Malden,	1	Sheffield,	1
Blauvelt, N. Y.,	1	Marlborough,	2	Sherborn,	1
Bolton,	1	Maynard,	1	South Hadley Falls,	1
Boston,	11	Medford,	2	Somerville,	2
Brimfield,	2	Melrose,	1	Springfield,	3
Brockton,	1	Middleborough,	1	Stow,	1
Brooklyn, N. Y.,	1	Milford,	2	Sudbury,	1
Byfield,	1	Montpelier, Vt.,	1	Uxbridge,	1
Cambridge,	1	Nantucket,	1	Wakefield,	2
Canton,	1	Needham,	2	Waltham,	1
Chelsea,	1	New Bedford,	1	Ware,	1
Dalton,	1	New Braintree,	1	Warren,	1
Danvers,	1	Newburyport,	1	Wellesley,	1
Deerfield,	1	New Canaan, Conn.,	1	Wenham,	1
Durham, Conn.,	1	Newington, Conn.,	1	West Tisbury,	1
Everett,	2	New Milford, Conn.,	1	Wilmette, Ill.,	1
Fairhaven,	2	Newport, R. I.,	1	Windsor, Conn.,	1
Fall River,	5	New Rochelle, N. Y.,	1	Winsted, Conn.,	1
Falmouth,	2	Newton,	5	Worcester,	7
Gloucester,	1	Newtown, Conn.,	1	Yalesville, Conn.,	1
Great Barrington,	2	Norwood,	1		
Groton,	1	Palmer,	2		

B. Home Addresses (classified by States).

	Number.	Per Cent.		Number.	Per Cent.
Connecticut,	12	7.14	New York,	5	2.97
Illinois,	1	.60	Rhode Island,	1	.60
Massachusetts,	143	85.11	Vermont,	1	.60
New Hampshire,	1	.60			
New Jersey,	4	2.38		168	100.00

C. Home Addresses (classified by Counties of Massachusetts).

	Number.	Per Cent.		Number.	Per Cent.
Barnstable,	2	1.40	Middlesex,	27	18.88
Berkshire,	7	4.90	Nantucket,	1	.70
Bristol,	9	6.29	Norfolk,	10	6.99
Dukes,	1	.70	Plymouth,	7	4.90
Essex,	27	18.88	Suffolk,	14	9.79
Franklin,	2	1.40	Worcester,	16	11.19
Hampden,	11	7.69			
Hampshire,	9	6.29		143	100.00

D. Nativity of Parents.

	Number.	Per Cent.
Neither parent foreign born,	130	77.38
Both parents foreign born,	25	14.88
Father (only) foreign born,	5	2.98
Mother (only) foreign born,	7	4.17
No statistics,	1	.60
	168	100.01

E. Education of Father.

	Number.	Per Cent.
Common school,	78	46.43
High school,	45	26.79
Business school,	15	8.93
College or university,	26	15.48
No statistics,	4	2.38
	168	100.01

F. Religious Census.

	Membership.		Preference.		Totals.	
	Number.	Per Cent.	Number.	Per Cent.	Number.	Per Cent.
Baptist,	10	5 95	6	3 57	16	9 52
Catholic,	10	5 95	1	.60	11	6 55
Congregationalist,	38	22.62	21	12 50	59	35 12
Episcopal,	15	8 93	3	1.79	18	10 71
Hebrew,	5	2 98	–	–	5	2 98
Lutheran,	3	1 79	1	.60	4	2 38
Methodist,	16	9 52	3	1.79	19	11 31
Presbyterian,	2	1 19	1	.60	3	1 79
Unitarian,	11	6 55	10	5 95	21	12 50
Universalist,	2	1 19	2	1 19	4	2 38
Miscellaneous,	4	2 38	4	2 38	8	4 76
	116	69.05	52	30.97	168	100.00

G. Occupation of Father.

	Number.	Per Cent.
Agriculture and horticulture,	42	25 00
Artisans,	33	19 64
Business,	46	27 38
Deceased or no statistics,	11	6 55
Miscellaneous,	14	8 33
Professional,	21	12 50
Retired,	1	.60
	168	100.00

H. Intended Vocations of Students.

	Number.	Per Cent.
Agriculture or horticulture (practical),	72	42 84
Agriculture or horticulture (professional),	61	36 31
Miscellaneous,	5	2 98
Professions,	4	2 38
Undecided or no statistics,	26	15 48
	168	99.99

I. Farm Experience.

	Number.	Per Cent.
Brought up on a farm,	53	31.55
Not brought up on a farm, and having had no, or practically no, farm experience,	60	35.71
Not brought up on a farm, but having had some farm experience,	55	32.74
	168	100.00

J. Miscellaneous Statistics.

Average age, ... 19.06 years.
Number signifying their intention to seek student labor, . . . 100 (59.52 per cent.)
Number boarding at the college dining hall, . . . 153 (91.07 per cent.)

TABLE VIII. — *Entrance Statistics of Freshmen Class.*

Number of applications,			273
Admitted,		200	
Matriculated,	168		
Failed to report,	32		
Total,		200	
Rejected,		73	
Total,			273
Admitted on certificate,			183
Admitted on examination,			3
Admitted on certificate and examination,			14
			200
Admitted without condition,			145
Admitted with condition,			55
			200

TABLE IX. — *Official Visits by Outside Organizations.*

Connecticut Valley Breeders' Association.
Garden and Club Workers.
Holyoke and Northampton Florists' and Gardeners' Club.
M. A. C. Improvement Association.
M. A. C. Short Course Association.
Massachusetts Dairymen's Association.
Massachusetts Federation for Rural Progress.
Massachusetts State Branch of the American Poultry Association.
Massachusetts State Grange.
Massachusetts State Poultry Association.
Massachusetts State Swine Breeders' Association.
New England Home Economics Association.
Western Massachusetts Library Club.
Worcester County Holstein Club.

Report of the Treasurer

For the Fiscal Year ending Nov. 30, 1914.

Balance Sheet.

		Dr.	Cr.
1913. Dec. 1.	To balance on hand,	$40,983 30	
1914. Nov. 30.	To receipts for fiscal year (see Schedule A),	625,937 16	
	Expenditures for fiscal year (see Schedule B),		$615,951 14
	Balance on hand,		50,969 32
		$666,920 46	$666,920 46

Statement of the First National Bank of Amherst with the Massachusetts Agricultural College.

		Dr.	Cr.
1913. Dec. 1.	Balance on hand,	$61,004 37[1]	
1914. Nov. 30.	Deposits for year,	616,504 87	
	Interest,	2,491 75	
	Disbursements as per warrants,		$614,618 25
	Balance on hand,		65,382 74[1]
		$680,000 99	$680,000 99

[1] These amounts are greater Dec. 1, 1913, by $29,841.81, and Nov. 30, 1914, by $37,396.40, on account of outstanding checks.

Schedule A. — Income.

	Items.	Totals.
Income from students and others,	. . .	$120,311 68
Tuition fees,	$2,267 00	
Laboratory fees,	5,188 27	
Rents,	5,152 70	
Dining hall,	57,812 19	
Department sales,	43,935 01	
Department transfers,	2,440 19	
Miscellaneous,	3,516 32	

SCHEDULE A. — INCOME — *Concluded.*

		Items.	Totals.
Income from grants by nation and State: —			
State aid,			$356,820 86
Income from endowment,		$3,313 32	
Appropriation for current expenses,		210,000 00	
Administration,	$30,000 00		
Maintenance,	85,000 00		
Instruction,	85,000 00		
Graduate school,	2,000 00		
Improvements,	8,000 00		
Appropriation for extension service,		50,000 00	
Appropriation for experiment station,		26,000 00	
Maintenance,	$20,000 00		
Feed law,	6,000 00		
Receipts from special appropriations,		67,507 54	
Federal aid,			75,633 33
Income from land grant of 1862,		$7,300 00	
Income from Hatch fund of 1887,		15,000 00	
Income from Adams fund of 1906,		15,000 00	
Income from Nelson fund of 1907,		16,666 67	
Income from Morrill fund of 1890,		16,666 66	
Income from Smith-Lever fund of 1914,		5,000 00	
Income from other sources: —			26,722 87
Income from experiment station,			
Fertilizer receipts,		$11,112 00	
Agricultural receipts,		2,494 49	
Cranberry receipts,		2,676 86	
Chemical receipts,		10,013 33	
Miscellaneous,		426 19	
Income from extension service,			5,023 27
Winter school receipts,		$1,308 85	
Summer school receipts,		738 45	
Correspondence course receipts,		832 86	
Itinerary instruction receipts,		905 25	
Miscellaneous,		1,237 86	
Received on account of student trust funds,			41,425 15
			$625,937 16

Classification of Income from Students and Others.

	Laboratory Fees.	Department Sales.	Transfers.	Rents.	Income.	Miscellaneous.	Dining Hall.	Tuition.	Total.
Agronomy,	$161 00	$16 70	–	–	–	–	–	–	$177 70
Agricultural education,	–	58 00	–	–	–	–	–	–	58 00
Animal husbandry,	173 00	3 50	–	–	–	–	–	–	176 50
Beekeeping,	–	8 15	–	–	–	–	–	–	8 15
Botany,	599 40	22 05	–	–	–	–	–	–	621 45
Chemistry,	2,598 14	19 53	$37 47	–	–	–	–	–	2,655 14
Dairy,	98 00	12,307 59	890 79	–	–	–	–	–	13,296 38
Equipment, 1914,	–	115 00	–	–	–	–	–	–	115 00
Entomology,	119 00	6 47	–	–	–	–	–	–	125 47
Farm,	–	20,083 19	1,128 17	–	–	–	–	–	21,211 36
Farm administration,	–	2 94	–	–	–	–	–	–	2 94
Floriculture,	–	2,954 81	36 43	–	–	–	–	–	2,991 24
Forestry,	–	14 40	50 70	–	–	–	–	–	65 10
General horticulture,	–	–	178 84	–	–	–	–	–	1,681 26
Grounds,	–	28 92	1 24	–	–	–	–	–	30 16
Improvements, 1914,	–	–	64 44	–	–	–	–	–	64 44
Landscape gardening,	395 90	–	1 77	–	–	–	–	–	397 67
Library,	–	124 67	28 97	–	$417 09	–	–	–	570 73
Market gardening,	–	1,601 37	3 17	–	–	–	–	–	1,604 54
Microbiology,	235 00	64 50	1 60	–	–	–	–	–	301 10
Physical education,	119 00	4 50	–	–	–	–	–	–	123 50
Pomology,	231 75	1,231 67	1 25	–	–	–	–	–	1,464 67
Poultry,	108 00	3,094 65	12 35	–	–	–	–	–	3,215 00
Veterinary,	–	11 82	3 00	–	–	–	–	–	14 82
Zoölogy,	346 00	5 17	–	–	–	–	–	–	351 17
Operating and maintenance,	–	–	12 60	–	–	$3,555 72	–	$2,267 00	5,835 32
North dormitory,	–	–	–	$2,094 17	–	–	–	–	2,094 17
South dormitory,	–	–	–	2,327 65	–	–	–	–	2,327 65
College residences,	–	–	–	678 88	–	–	–	–	678 88
Executive order,	–	2 50	–	–	–	–	–	–	2 50
President's office,	–	50	–	–	–	–	–	–	50
Treasurer's office,	–	17	–	–	–	–	–	–	17
Salaries,	–	236 81	–	–	–	–	–	–	236 81
Dining hall,	–	–	–	–	–	–	$57,812 19	–	57,812 19
Totals,	$5,184 19	$43,522 00	$2,452 79	$5,100 70	$417 09	$3,555 72	$57,812 19	$2,267 00	$120,311 68

Schedule B. — Expenditures for Fiscal Year.

	Items.	Totals.
College expenses,	. . .	$316,752 76
Administration,	$31,067 12	
Maintenance,	162,584 99	
Instruction,	123,100 65	
Experiment station,	. . .	81,587 92
Administration,	$1,416 13	
Feed inspection,	5,897 93	
Fertilizer law,	9,744 92	
Salaries,	36,202 83	
Departments,	28,326 11	
Extension service,	. . .	56,104 76
Salaries,	$28,614 13	
Travel,	9,361 54	
Department,	18,129 09	
Special appropriation,	. . .	58,307 54
Student trust funds,	. . .	44,797 09
Dining hall,	. . .	58,401 07
		$615,951 14

Analysis of College Expenditures.

Administration.	Office Expense.	Salaries and Labor.	Travel.	Minor Equipment.	Building Supplies.	Publicity and Lectures.	Student Activity.	Commencement.	Miscellaneous.	Total.
Dean's office,	$165 08	$296 56	-	$49 60	-	-	-	-	-	$511 24
Executive order,	-	-	$1,616 20	-	-	$1,689 47	$773 24	$502 35	$1,615 21	6,196 47
President's office,	682 92	104 24	66 85	-	$18 48	-	-	-	-	872 49
Registrar's office,	323 61	77 63	15 20	19 92	2 89	-	-	-	-	439 25
Treasurer's office,	549 92	366 53	220 83	56 01	29 66	-	-	-	30 45	1,253 40
Administration (salaries),	-	21,794 27	-	-	-	-	-	-	-	21,794 27
Totals,	$1,721 53	$22,639 23	$1,919 08	$125 53	$51 03	$1,689 47	$773 24	$502 35	$1,645 66	$31,067 12

Maintenance.	Office Expense.	Labor.	Laboratory Supplies.	Refunds.	Minor Equipment.	Building Supplies.	Travel.	General Expense.	Miscellaneous.	Salaries.	Totals.
Academic maintenance: —											
Agricultural economics,	$62 75	$18 90	$14 88	-	$0 48	-	$6 15	-	-	-	$103 16
Agricultural education,	110 36	87 75	139 15	-	3 61	-	38 99	-	$6 79	-	386 65
Agronomy,	62 00	61 42	132 33	$15 50	81	-	22 85	-	-	-	294 91
Animal husbandry,	69 50	152 73	66 81	10 00	24 58	-	269 82	-	-	-	593 44
Beekeeping,	133 42	1,196 33	171 96	-	116 62	$56 15	1 62	-	-	-	1,676 10
Botany,	196 18	631 75	480 29	74 70	30 51	48 00	-	-	-	-	1,461 43
Chemistry,	184 83	1,023 10	2,457 03	649 45	85 27	94 81	5 30	-	-	-	4,499 79
Dairying,	127 94	1,083 72	14,909 14	13 50	290 53	80 24	44 45	-	-	-	16,549 52
Economics and sociology,	30 76	-	1 09	-	80	-	-	-	-	-	32 65
Entomology,	37 67	260 68	159 20	6 00	51 46	134 71	14 31	-	-	-	664 03
Farm administration,	174 47	55 32	39 08	-	73 68	-	34 57	-	-	-	377 12
Floriculture,	120 51	2,614 89	1,002 79	-	42 02	124 87	100 39	-	-	-	4,005 47
Forestry,	72 46	49 49	154 25	-	108 37	-	18 03	-	-	-	402 60
History and government,	5 17	-	27	-	-	-	5 17	-	-	-	10 61
Landscape gardening,	15 91	9 57	310 00	5 50	34 38	-	19 20	-	-	-	394 56
Language and literature,	50 19	64 00	143 21	-	20 28	2 91	-	-	6 00	-	286 59

Market gardening,	22 87	2,492 18	1,069 83	–	92 36	71 15	15 57	–	–	–	3,763 96
Mathematics,	51 97	79 85	18 37	–	–	19 28	3 36	–	–	–	172 83
Microbiology,	124 49	272 76	278 81	169 50	24 20	25 03	6 31	–	–	–	901 10
Military science,	171 52	796 69	49 88	7 75	67 74	20 88	–	–	212 00	–	1,326 46
Physical education,	102 49	86 34	137 92	–	35 73	8 64	344 78	–	–	–	715 90
Physics,	35 68	275 41	154 86	–	151 82	27 75	–	–	–	–	645 52
Pomology,	96 42	2,567 98	793 72	2 50	335 69	38 31	12 67	–	–	–	3,847 29
Poultry husbandry,	347 06	1,466 65	2,976 75	14 50	223 24	33 87	18 60	–	–	–	5,080 67
Rural engineering,	29 41	–	11 86	–	53 56	–	1 50	–	–	–	96 33
Rural sociology,	5 22	–	26 10	–	–	–	9 44	–	–	–	40 76
Veterinary science,	6 31	300 95	551 73	–	60 72	65 00	11 82	–	–	–	996 53
Zoölogy and geology,	53 79	207 92	347 43	11 50	120 63	38	31 05	–	–	–	772 70
General maintenance: —											
Equipment, 1914,	–	–	–	–	–	–	–	11,271 71	–	–	11,271 71
Farm,	–	–	–	–	–	–	–	28,869 16	–	–	28,869 16
General horticulture,	–	–	–	–	–	–	–	4,316 98	–	–	4,316 98
Graduate school,	–	–	–	–	–	–	–	90 99	–	–	90 99
Grounds,	–	–	–	–	–	–	–	3,026 66	–	–	3,026 66
Library,	–	–	–	–	–	–	–	6,761 82	–	–	6,761 82
Operating and maintenance,	–	–	–	–	–	–	–	49,640 03	–	–	49,640 03
Improvement, 1914,	–	–	–	–	–	–	–	8,508 96	–	–	8,508 96
	$2,501 35	$15,856 38	$26,598 74	$980 40	$2,049 09	$851 98	$1,035 95	$112,486 31	$224 79	–	$162,584 99
Instruction: —											
Salaries,	–	–	–	–	–	–	–	–	–	$123,100 65	$123,100 65
Grand total,	–	–	–	–	–	–	–	–	–	–	$316,752 76

Current Accounts.

Disbursements and Receipts.

Accounts.	Disbursements from Dec. 1, 1913, to Nov. 30, 1914.	Receipts from Dec. 1, 1913, to Nov. 30, 1914.	Apportionment for Year ending Nov. 30, 1914.	Balance to Credit.
Administration: —				
Dean's office,	$511 24	–	$500 00	—$11 24
Executive order,	6,196 47	$2 50	5,700 00	—493 97
President's office,	872 49	50	1,000 00	128 01
Registrar's office,	439 25	–	400 00	—39 25
Salaries,	21,794 27	236 81	21,000 00	—557 46
Treasurer's office,	1,253 40	17	900 00	—353 23
State Treasurer,	–	30,000 00	–	–
Maintenance: —				
Agricultural economics,	103 16	–	125 00	21 84
Agricultural education,	386 65	58 00	300 00	—28 65
Agronomy,	294 91	177 70	175 00	57 79
Animal husbandry,	593 44	176 50	200 00	—216 94
Beekeeping,	1,676 10	8 15	1,600 00	—67 95
Botany,	1,461 43	621 45	700 00	—139 98
Chemistry,	4,499 79	2,655 14	1,800 00	—44 65
Dairying,	16,549 52	13,296 38	2,300 00	—953 14
Economics and sociology,	32 65	–	50 00	17 35
Entomology,	664 03	125 47	750 00	211 44
Farm administration,	377 12	2 94	325 00	—49 18
Floriculture,	4,005 47	2,991 24	800 00	—214 23
Forestry,	402 60	65 10	450 00	112 50
History and government,	10 61	–	50 00	39 39
Landscape gardening,	394 56	397 67	440 00	443 11
Language and literature,	286 59	–	400 00	113 41
Market gardening,	3,763 96	1,604 54	1,700 00	—459 42
Mathematics,	172 83	–	200 00	27 17
Microbiology,	901 10	301 10	600 00	–
Military science,	1,326 46	–	1,350 00	23 54
Physical education,	715 90	123 70	500 00	92 40
Physics,	645 52	–	500 00	—145 52
Pomology,	3,847 29	1,464 67	1,800 00	—582 62
Poultry husbandry,	5,080 67	3,215 00	2,000 00	134 33
Rural engineering,	96 33	–	200 00	103 67
Rural sociology,	40 76	–	25 00	—15 76
Veterinary science,	996 53	14 82	750 00	—231 71
Zoölogy and geology,	772 70	351 17	250 00	—171 53
Maintenance, general: —				
Equipment, 1914,	11,271 71	115 00	12,000 00	843 29
Farm,	28,869 16	21,211 36	4,500 00	—3,157 80
General horticulture,	4,316 98	1,681 26	2,300 00	—335 72
Graduate school,	90 99	–	100 00	9 01
Grounds,	3,026 66	30 16	3,250 00	253 50
Improvement, 1914,	8,508 96	64 44	8,000 00	—444 52
Library,	6,761 82	570 73	5,550 00	—641 09
Operating and maintenance,	49,640 03	10,936 02	50,000 00	359 97
State Treasurer, maintenance,	–	93,000 10	–	–
Endowment fund,	–	10,613 32	–	–
Instruction: —				
Salaries,	123,100 65	–	–	–
United States Treasurer: —				
Morrill fund,	–	16,666 66	–	–
Nelson fund,	–	16,666 67	–	–
State Treasurer: —				
Instruction,	–	85,000 00	–	–
Graduate school,	–	2,000 00	–	–
	$316,752 76	$316,446 14	–	–
Balance beginning fiscal year, Dec. 1, 1913,	–	16,379 05	–	–
Balance on hand Nov. 30, 1914,	16,072 43	–	–	–
	$332,825 19	$332,825 19	–	–

College Accounts.

Comparative Disbursements and Receipts for 1913-14.

Accounts.	Disbursements.		Receipts.	
	1913.	1914.	1913.	1914.
Agricultural economics,	$182 82	$103 16	–	–
Agricultural education,	678 94	386 65	$250 99	$58 00
Agronomy,	405 86	294 91	109 08	177 70
Animal husbandry,	315 10	593 44	30	176 50
Beekeeping,	–	1,676 10	–	8 15
Botany,	1,643 99	1,461 43	734 19	621 45
Chemistry,	4,420 90	4,499 79	2,784 75	2,655 14
Dairying,	6,611 35	16,549 52	4,549 40	13,296 38
Dean's office,	491 84	511 24	–	–
Economics and sociology,	79 36	32 65	–	–
Entomology,	1,573 09	664 03	191 97	125 47
Equipment,	15,421 90	11,271 71	–	115 00
Executive order,	6,297 82	6,196 47	–	2 50
Farm administration,	366 29	377 12	33 85	2 94
Farm,	24,830 70	28,869 16	20,858 81	21,211 36
Floriculture,	4,047 00	4,005 47	3,320 64	2,991 24
Forestry,	221 81	402 60	–	65 10
General horticulture,	3,735 20	4,316 98	1,425 67	1,681 26
Graduate school,	33 25	90 99	–	–
Grounds,	2,937 01	3,026 66	3 08	30 16
History and government,	37 54	10 61	–	–
Hospital,	4,379 20	–	26 50	–
Improvements, 1914,	–	8,508 96	–	64 44
Landscape gardening,	387 03	394 56	489 10	397 67
Language and literature,	300 69	286 59	–	–
Library,	6,523 60	6,761 82	561 25	570 73
Market gardening,	3,633 23	3,763 96	2,131 12	1,604 54
Mathematics,	161 48	172 83	–	–
Military,	1,647 19	1,326 46	5 50	–
Microbiology,	449 31	901 10	210 00	301 10
Physical education,	754 88	715 90	142 50	123 70
Physics,	403 43	645 52	2 30	–
Pomology,	3,638 96	3,847 29	1,855 82	1,464 67
Poultry husbandry,	4,104 22	5,080 67	2,159 18	3,215 00
President's office,	934 99	872 49	4 20	50
Registrar's office,	401 15	439 25	–	–
Rural engineering,	–	96 33	–	–
Rural sociology,	27 86	40 76	–	–
Salaries,	129,642 00	144,894 92	250 00	236 81
Treasurer's office,	1,118 53	1,253 40	11 27	17
Veterinary,	1,917 50	996 53	21 65	14 82
Zoölogy and geology,	581 09	772 70	333 10	351 17
Operating and maintenance,	48,742 64	49,640 03	9,757 60	10,936 02
State Treasurer: —				
Endowment fund,	–	–	10,613 32	10,613 32
Graduate school,	–	–	–	2,000 00
Maintenance,	–	–	80,000 00	93,000 00
Instruction,	–	–	75,000 00	85,000 00
Administration,	–	–	30,000 00	30,000 00
United States Treasurer: —				
Morrill fund,	–	–	16,666 66	16,666 66
Nelson fund,	–	–	16,666 67	16,666 67
	$284,080 75	$316,752 76	$281,171 18	$316,446 14
Balance beginning fiscal year,	–	–	19,288 62	16,379 05
Balance on hand at close of fiscal year,	16,379 05	16,072 43	–	–
	$300,459 80	$332,825 19	$300,459 80	$332,825 19

College Accounts — *Concluded.*

Summary.

	Disbursements.	Credits.
Cash on hand Dec. 1, 1913,	–	$16,379 05
Institution receipts Nov. 30, 1914,	–	62,499 49
State Treasurer receipts Nov. 30, 1914,	–	220,613 32
United States Treasurer's receipts Nov. 30, 1914,	–	33,333 33
Total disbursements,	$316,752 76	–
	$316,752 76	$332,825 19
Bills receivable Dec. 1, 1913, deducted,	–	3,827 63
Bills payable Dec. 1, 1913, deducted,	2,496 39	–
	$314,256 37	$328,997 56
Bills receivable Nov. 30, 1914,	–	6,855 03
Bills payable Nov. 30, 1914,	2,893 65	–
Balance,	18,702 57	–
	$335,852 59	$335,852 59

College Equipment, 1914.

	Disbursements Fiscal Year.		Disbursements Fiscal Year.
Farm,	$678 30	Landscape gardening,	$140 00
Microbiology,	2,540 30	Mathematics,	75 00
O. and M. power plant,	885 91	Farm dairy,	388 19
Dairy,	873 30	Physical education,	265 00
President's office,	903 57	Physics,	377 63
Dean's office,	102 90	Pomology,	226 50
Treasurer's office,	480 28	Poultry husbandry,	218 93
General horticulture,	190 93	Veterinary,	36 83
Library,	125 00	Zoölogy,	76 50
Dining hall,	750 00	Beekeeping,	55 86
Agricultural education,	–	South College,	115 00
Agronomy,	151 40	Experiment station,	150 00
Animal husbandry,	750 00	Chapel,	246 81
Chemistry,	314 70	Agricultural economics,	36 50
Entomology,	102 75		
Farm administration,	13 62		$11,271 71
Forestry,	–		

Farm Disbursements.

	Labor.	Equipment.	Feed.	Fertilizer.	Seeds.	Miscellaneous.	Supplies.	Improvements.	Totals.
Dairy,	$1,610 79	$129 15	–	–	–	–	$2,030 79	–	$3,770 73
Cattle,	4,567 93	–	$5,200 43	–	–	$2,013 19	–	–	11,781 55
Horses,	1,533 53	–	1,285 16	–	–	–	451 61	–	3,270 30
Swine,	114 79	–	270 12	–	–	50 90	–	–	435 81
Sheep,	134 12	–	–	–	–	34 83	–	–	168 95
Field crops,	2,795 56	–	–	$1,168 40	$307 85	36 14	–	–	4,307 95
Tools and machinery,	–	–	–	–	–	533 46	–	–	533 46
Miscellaneous,	3,737 98	–	–	–	–	–	73 25	$789 18	4,600 41
	$14,494 70	$129 15	$6,755 71	$1,168 40	$307 85	$2,668 52	$2,555 65	$789 18	$28,869 16

Farm Credits.

	Milk.	Stock.	Sundry.	Miscellaneous.	Hogs.	Wool.	Corn.	Hay.	Roots.	Labor.	Potatoes.	Totals.
Dairy,	$5,697 81	–	$6 57	–	–	–	–	–	–	–	–	$5,704 38
Cattle,	11,958 95	–	262 74	–	–	–	–	–	–	–	–	12,221 69
Horses,	–	$50 00	922 21	–	–	–	–	–	–	–	–	972 21
Swine,	–	–	–	$1 50	$115 50	–	–	–	–	–	–	117 00
Sheep,	–	30 00	–	–	–	$24 66	–	–	–	–	–	54 66
Feed crops,	–	–	–	–	–	–	$1 75	$425 13	$241 55	–	$366 80	1,035 23
Tools and machinery,	–	–	–	–	–	–	–	–	–	–	–	–
Miscellaneous,	–	–	283 62	–	–	–	–	–	–	$822 57	–	1,106 19
	$17,656 76	$80 00	$1,475 14	$1 50	$115 50	$24 66	$1 75	$425 13	$241 55	$822 57	$366 80	$21,211 36

Agricultural Division.

Disbursements and Receipts.

	Disbursements.	Receipts.
Agronomy,	$294 91	$177 70
Animal husbandry,	593 44	176 50
Dairying,	16,549 52	13,296 38
Farm,	28,869 16	21,211 36
Farm administration,	377 12	2 94
Poultry husbandry,	5,080 67	3,215 00
Division totals,	$51,764 82	$38,079 88

Summary.

	Dr.	Cr.
By total division receipts,	. . . . .	$38,079 88
By bills receivable,	. . . . .	5,071 70
By net apportionment,	. . . . .	9,500 00
To total disbursements,	$51,764 82	
To bills payable,	236 11	
Balance,	650 65	
	$52,651 58	$52,651 58

Inventory of Quick Assets.

	Nov. 30, 1913.	Nov. 30, 1914.
Inventory of produce,	$6,431 98	$8,938 35
Inventory of cattle,	11,935 00	13,645 00
Inventory of swine,	286 00	375 00
Inventory of horses,	5,150 00	5,450 00
Inventory of poultry,	1,598 70	941 25
Inventory of sheep,	443 00	647 00
	$25,844 68	$29,996 60

Horticultural Division.

Disbursements and Receipts.

	Disbursements.	Receipts.
Floriculture,	$4,005 47	$2,991 24
Forestry,	402 60	65 10
General horticulture,	4,316 98	1,681 26
Grounds,	3,026 66	30 16
Landscape gardening,	394 56	397 67
Market gardening,	3,763 96	1,604 54
Pomology,	3,847 29	1,464 67
Division totals,	$19,757 52	$8,234 64

HORTICULTURAL DIVISION — *Concluded.*

Summary.

	Dr.	Cr.
By total division receipts,	. . . . .	$8,234 64
By bills receivable,	. . . . .	486 16
By apportionment,	. . . . .	10,300 00
To total division disbursements,	$19,757 52	
To bills payable,	162 81	
By balance,	. . . . .	899 53
	$19,920 33	$19,920 33

Inventory of Quick Assets.

	Nov. 30, 1913.	Nov. 30, 1914.
Floriculture,	. . . . .	$523 50
Market gardening,	. . . . .	107 50
Pomology,	. . . . .	612 50
General horticulture (live stock),	$1,935 00	1,625 00
Inventory of supplies,	713 25	
	$2,648 25	$2,868 50

Expense Operating and Maintenance.

	Salaries.	Labor.	Fuel and Water.	Repairs.	Supplies.	Tools.	Architect.	Engineer.	Miscellaneous.	Totals.
General: —										
General superintendent,	$2,281 84	–	–	–	–	–	–	–	–	$2,281 84
Office,	–	$1,112 84	–	–	–	–	–	–	–	1,112 84
General expenses,	–	–	–	–	$2,788 22	–	–	–	–	2,788 22
Power plant: —										
Heat,	–	4,001 19	$18,195 67	$673 58	148 73	–	–	–	–	23,019 17
Light,	–	655 58	101 34	455 44	66 87	–	–	–	–	1,279 23
Tools,	–	–	–	–	–	$380 86	–	–	–	380 86
Waiting station janitor,	–	23 84	–	–	–	–	–	–	–	23 84
Amherst Water Company,	–	–	1,529 62	–	–	–	–	–	–	1,529 62
Night watch,	–	1,263 82	–	–	–	–	–	–	–	1,263 82
Mail service,	–	338 53	–	–	–	–	–	–	–	338 53
Water main,	–	660 73	–	–	–	–	–	–	–	660 73
Steam main,	–	319 83	–	–	–	–	–	–	–	319 83
Sewers and cesspools,	–	6 75	–	–	–	–	–	–	–	6 75
Amherst Gas Company,	–	–	37 87	–	–	–	–	–	–	37 87
Electric light circuit,	–	434 29	–	–	–	–	–	–	–	434 29
Expert services,	–	–	–	–	–	–	$733 52	–	–	733 52
Walks,	–	234 84	–	–	–	–	–	–	–	234 84
Emergency maintenance,	–	1,594 92	–	–	–	–	–	–	–	1,594 92
Drains,	–	84 26	–	–	–	–	–	–	–	84 26
Fire department,	976 20	129 67	–	–	115 77	–	–	–	$9 98	1,231 62
Sundry,	–	–	–	–	–	–	–	–	2,002 28	2,002 28
Totals,	$3,258 04	$10,861 09	$19,864 50	$1,129 02	$3,119 59	$380 86	$733 52	–	$2,012 26	$41,358 88

Expense Operating and Maintenance — Continued.

College Buildings.	Electric Repairs.	Plumbing Repairs.	Heat Repairs.	C. and M. Repairs.	Janitor.	Bell Ringing.	Sundry.	Totals.
Animal husbandry,	–	$5 97	$44 69	$5 60	–	–	–	$56 26
Horse barn,	$0 62	24 49	–	57 62	–	–	–	82 73
Dairy barn,	62	33 32	17 26	88 69	–	–	–	139 89
Young stock barn,	36 01	30 56	–	36 88	–	–	–	103 45
Power building,	5 36	18 76	58 82	94 77	$156 35	–	–	334 06
Chemical building,	2 70	50 10	69 10	10 90	–	–	–	132 80
Poultry building,	4 59	11 94	–	62 67	–	–	–	79 20
Dairy building,	19 68	106 61	24 45	65 74	–	–	–	216 48
Dining hall,	–	–	–	20 70	–	–	–	20 70
Drill hall,	3 44	39 26	47 13	76 95	–	–	–	166 78
Veterinary,	1 06	10 06	37	8 64	–	–	–	20 13
Apiary,	20 64	20 01	88 38	55 84	–	–	–	184 87
Mathematics building,	5 27	17 24	11 74	69 62	–	–	–	103 87
Entomology,	1 65	37 47	69 80	273 37	–	–	–	382 29
Clark Hall,	1 33	25 93	104 37	113 65	–	–	–	245 28
French Hall,	3 14	2 75	19 31	9 41	–	–	–	34 61
Wilder Hall,	7 34	4 78	37	18 76	–	–	–	31 25
Old Durfee range,	67	–	5 38	35 38	–	–	–	41 43
Horticulture barns,	30	37	–	2 52	–	–	–	3 19
Physics building,	53	39 07	4 32	351 77	–	–	–	395 69
East experiment station,	92	13 78	50 81	37 37	–	–	–	102 88
West experiment station,	2 70	13 43	9 24	41 82	–	–	–	67 19
Experiment station barn,	–	6 05	–	160 08	–	–	–	166 13
P. and A. chemistry barn,	1 25	5 89	1 13	23 77	–	–	–	32 04
Microbiology,	10 50	123 99	153 68	195 66	–	–	$500 00	983 83
Farm cottage,	–	1 74	–	38 02	–	–	–	39 76
North College,	44 48	40 59	8 45	193 73	447 98	–	140 57	875 80
South College,	141 88	197 06	53 51	633 18	572 06	–	119 68	1,717 37
Chapel,	27 94	11 88	38 40	48 68	245 82	$100 00	–	472 72
Total,	$344 62	$893 10	$880 71	$2,831 79	$1,422 21	$100 00	$760 25	$7,232 68

Expense Operating and Maintenance — Concluded.

College Buildings.	Electric Repairs.	Plumbing Repairs.	Heat Repairs.	C. and M. Repairs.	Janitor.	Bell Ringing.	Sundry.	Totals.
College residences: —								
Harlow place,	–	–	–	$9 61	–	–	–	$9 61
Kellogg place,	–	$3 89	–	28 40	–	–	–	32 29
President's house,	$56 70	31 26	$45 69	475 76	–	–	$43 14	652 55
Division of horticulture, house,	91	9 23	3 96	65 46	–	–	–	79 56
Registrar's house,	7 71	88	–	82 44	–	–	–	91 03
Farm superintendent's house,	2 46	8 78	–	34 40	–	–	–	45 64
Farm help's house,	1 84	49 49	–	2 39	–	–	–	53 72
Stockbridge house,	–	2 74	–	5 89	–	–	–	8 63
Farm cottage,	2 90	8 29	1 76	48 57	–	–	13 92	75 44
Totals,	$72 52	$114 56	$51 41	$152 92	–	–	$57 06	$1,048 47

Summary.

General,	$41,358 88
College buildings,	7,232 68
College residences,	1,048 47
	$49,640 03

Experiment Station.

Disbursements and Receipts.

Accounts.	Disbursements from Dec. 1, 1913, to Nov. 30, 1914.	Receipts from Dec. 1, 1913, to Nov. 30, 1914.	Apportionment for Year ending Nov. 30, 1914.	Balance to Credit.
Administration,	$1,416 13	$4 92	$1,800 00	$388 79
Agriculture,	5,058 48	2,494 49	2,100 00	—463 99
Asparagus,	757 60	–	700 00	—57 60
Botanical,	1,895 80	50 00	1,500 00	—345 80
Chemical,	10,252 46	10,013 33	1,100 00	860 87
Cranberry,	2,886 76	2,676 86	3,000 00	2,790 10
Entomology,	556 56	4 50	700 00	147 94
Feed inspection,	5,897 93	6,018 67	–	1,018 14
Fertilizer inspection,	9,744 92	11,112 00	–	2,853 70
Freight and express,	532 56	24 55	300 00	—208 01
Graves orchard,	789 08	129 25	800 00	140 17
Horticultural,	1,936 83	11 46	1,350 00	—575 37
Library,	248 75	–	300 00	51 25
Meteorology,	374 24	–	375 00	76
Poultry,	1,066 63	4 17	900 00	—162 46
Publications,	912 47	–	1,700 00	787 53
Salaries,	36,202 83	18 67	37,015 86	831 70
Treasurer's office,	364 44	–	350 00	—14 44
Veterinary,	597 15	–	725 00	127 85
Hatch fund,	–	15,000 00	–	–
Adams fund,	–	15,000 00	–	–
State fund,	–	20,000 00	–	–
Miscellaneous,	96 30	160 00	–	–
Totals,	$81,587 92	$82,722 87	$54,715 86	$8,171 13
Balance on hand beginning fiscal year Dec. 1, 1913,	–	7,151 90	–	–
Balance on hand Nov. 30, 1914,	8,298 67	–	–	–
	$89,874 77	$89,874 77	$54,715 86	$8,171 13

Comparative Disbursements and Receipts, 1913–14.

Accounts.	Disbursements.		Receipts.	
	1913.	1914.	1913.	1914.
Administration,	$860 79	$1,416 13	$4 54	$4 92
Agriculture,	4,841 79	5,058 48	2,746 36	2,494 49
Asparagus,	483 27	757 60	–	–
Botanical,	1,672 90	1,895 80	–	50 00
Chemical,	9,362 54	10,252 46	9,129 76	10,013 33
Cranberry,	3,135 53	2,886 76	5,884 50	2,676 86
Entomology,	425 96	556 56	3 20	4 50
Feed inspection,	6,184 05	5,897 93	6,000 00	6,018 67
Fertilizer inspection,	10,560 77	9,744 92	10,580 00	11,112 00
Freight and express,	248 24	532 56	56	24 55
Graves orchard,	466 93	789 08	399 04	129 25
Horticultural,	1,492 20	1,936 83	78 20	11 46
Library,	64 00	248 75	–	–
Meteorology,	299 27	374 24	–	–
Poultry,	910 51	1,066 63	–	4 17
Publications,	978 37	912 47	–	–
Salaries,	32,679 14	36,202 83	–	18 67
Treasurer's office,	373 27	364 44	–	–
Veterinary,	718 02	597 15	–	–
Hatch fund,	–	–	15,000 00	15,000 00
Adams fund,	–	–	15,000 00	15,000 00
State fund,	–	–	15,000 00	20,000 00
Miscellaneous,	–	96 30	–	160 00
Totals,	$75,757 55	$81,587 92	$79,825 16	$82,722 87
Balance beginning fiscal year,	–	–	3,084 29	7,151 90
Balance on hand at close of fiscal year,	7,151 90	8,298 67	–	–
	$82,909 45	$89,874 77	$82,909 45	$89,874 77

Experiment Station — *Concluded.*

Analysis of Experiment Station Accounts.

	Adams Fund.	Fertilizer Law.	Feed Law.	Hatch Fund.	State Fund.	Totals.
Salaries,	$13,905 26	$6,354 35	$3,778 30	$12,828 95	$9,468 62	$46,335 48
Labor,	564 29	762 94	128 77	930 56	14,087 37	16,473 93
Publication,	–	813 27	1,048 96	92 14	570 09	2,524 46
Postage and stationery,	12 52	120 42	28 60	2 53	1,207 15	1,371 22
Freight and express,	–	39 93	9 87	–	549 05	598 85
Heat, light, water and power,	–	191 60	38 38	8 63	202 31	440 92
Chemistry and laboratory supplies,	139 07	554 88	177 55	115 06	456 41	1,442 97
Seeds, plants and sundry supplies,	302 23	49 28	18 23	65 65	1,682 10	2,117 49
Fertilizers,	123 33	50	–	675 16	373 72	1,172 71
Feeding stuffs,	–	–	–	–	1,402 18	1,402 18
Library,	20 34	6 00	–	12 71	698 53	737 58
Tools, machinery and appliances,	–	3 00	–	29 60	546 66	579 26
Furniture and fixtures,	3 36	–	35 00	-	508 48	546 84
Scientific apparatus and specimens,	36 51	38 23	20 50	11 75	634 48	741 47
Live stock,	–	–	–	41 00	175 55	216 55
Traveling expenses,	82 06	752 01	488 18	–	2,075 24	3,397 49
Contingent expenses,	–	–	80 00	–	97 77	177 77
Buildings and land,	19 65	58 51	45 59	–	1,087 01	1,210 76
Miscellaneous,	–	–	–	–	99 99	99 99
	$15,208 62	$9,744 92	$5,897 93	$14,813 74	$35,922 71	$81,587 92

Summary.

	Disbursements.	Receipts.
Cash on hand Dec. 1, 1913,	–	$8,298 67
Receipts from State Treasurer,	–	26,000 00
Receipts from United States Treasurer,	–	30,000 00
Receipts from other sources,	–	26,722 87
Total disbursements,	$81,587 92	–
	$81,587 92	$91,021 44
Bills receivable Nov. 30, 1914,	–	945 25
Bills payable Nov. 30, 1914,	1,002 38	–
Balance,	9,376 39	–
	$91,966 69	$91,966 69

Extension Service.

Disbursements and Receipts.

Accounts.	Disbursements.	Receipts.	Apportionment.	Balance.
Administration,	$2,321 53	$34 14	$2,400 00	$112 61
Agricultural education,	3,351 27	121 55	2,500 00	—729 72
Agricultural economics,	1,029 13	139 84	800 00	—89 29
Animal husbandry,	625 05	64 80	683 33	123 08
Auto. Dem. outfit,	813 30	15 56	1,150 00	352 26
Apple packing school,	65 70	280 00	100 00	314 30
Beekeeping,	49 47	–	200 00	150 53
Boys' camp,	804 51	393 00	200 00	—211 51
Civic improvement,	734 02	132 49	600 00	—1 53

EXTENSION SERVICE — *Continued.*

Disbursements and Receipts — Concluded.

ACCOUNTS.	Disbursements.	Receipts.	Apportionment.	Balance.
Community service,	$672 69	$7 70	$600 00	—$64 99
Conference rural social workers,	563 48	–	500 00	—63 48
Correspondence courses,	1,264 86	832 86	400 00	—32 00
County agents,	166 83	–	200 00	33 17
Dairying,	305 57	–	283 33	—22 24
Director's office,	1,810 42	70 82	1,900 00	160 40
Farm management,	1,131 49	34 33	1,276 67	179 51
Farmers' week,	1,082 16	84 85	900 00	—97 31
Home economics,	707 28	79 85	912 50	285 07
Itinerary instruction,	2,481 01	905 25	1,600 00	24 24
Library extension,	199 43	–	200 00	57
M. A. C. Improvement Association,	132 65	71 46	100 00	38 81
Pomology,	902 73	7 30	1,083 33	187 90
Poultry convention,	328 92	12 00	200 00	—116 92
Poultry husbandry,	132 65	8 02	200 00	75 37
Physical education,	427 74	–	208 34	—219 40
Salaries,	28,614 13	45 00	28,807 21	238 08
Summer school,	3,316 78	738 45	2,500 00	—78 33
Ten weeks' school,	1,942 16	944 00	1,500 00	501 84
Tree warden's school,	127 80	–	100 00	—27 80
Publishing and printing,	–	–	208 34	208 34
Furniture and fixtures,	–	–	208 33	208 33
Contingent expenses,	–	–	98 62	98 62
From State Treasurer,	–	50,000 00	–	–
From United States Treasurer,	–	5,000 00	–	–
Smith-Lever balance,	–	–	–	833 33
Unapportioned balance,	–	–	–	8,323 88
Totals,	$56,104 76	$60,023 27	$52,620 00	$10,695 72
Balance beginning fiscal year Dec. 1, 1913,	–	6,777 21	–	–
Balance on hand Nov. 30, 1914,	10,695 72	–	–	–
	$66,800 48	$66,800 48	–	–

Summary.

	Disbursements.	Receipts.
Balance Dec. 1, 1913,	–	$6,777 21
Receipts Nov. 30, 1914,	–	5,023 27
Received from State Treasurer,	–	50,000 00
Received from U. S. Treasurer,	–	5,000 00
Disbursements to Nov. 30, 1914,	$56,104 76	–
	$56,104 76	$66,800 48
Bills receivable Dec. 1, 1913, deducted,	–	133 29
Bills payable Dec. 1, 1913, deducted,	505 96	–
	$56,610 72	$66,667 19
Bills receivable Nov. 30, 1914,	–	899 26
Bills payable Nov. 30, 1914,	468 87	–
Balance,	10,486 86	–
	$67,566 45	$67,566 45

Extension Service — *Concluded.*

Analysis of Extension Service Disbursements.

	Travel.	Equipment.	Laboratory Expense.	Printing.	Office Supplies.	Instruction and Lectures.	Salaries.	Miscellaneous.	Totals.
Administration,	$1,042 65	$101 45	–	$884 25	–	–	$28,614 13	$293 18	$30,935 66
Agricultural education,	743 99	1,337 66	–	–	$14 66	–	–	1,254 96	3,351 27
Agricultural economics,	686 70	342 43	–	–	–	–	–	–	1,029 13
Animal husbandry,	406 71	218 34	–	–	–	–	–	–	625 05
Auto. Dem. outfit,	514 10	101 51	–	–	2 00	–	–	195 69	813 30
Apple packing school,	3 44	–	–	–	–	–	–	62 26	65 70
Beekeeping,	–	27 30	–	–	–	–	–	22 17	49 47
Boys' Camp,	70 47	275 49	–	–	–	–	–	458 55	804 51
Civic improvement,	195 82	538 20	–	–	–	–	–	–	734 02
Community service,	593 20	79 49	–	–	–	–	–	–	672 69
Conference rural social workers,	300 49	262 99	–	–	–	–	–	–	563 48
Correspondence courses,	106 12	201 02	–	–	674 93	–	–	282 79	1,264 86
County agents,	166 83	–	–	–	–	–	–	–	166 83
Dairying,	158 29	147 28	–	–	–	–	–	–	305 57
Director's office,	20 00	476 63	–	–	1,094 39	–	–	219 40	1,810 42
Farm management,	716 86	414 63	–	–	–	–	–	–	1,131 49
Farmer's Week,	377 96	–	–	–	704 20	–	–	–	1,082 16
Home economics,	478 18	229 10	–	–	–	–	–	–	707 28
Itinerant instruction,	1,442 14	1,038 87	–	–	–	–	–	–	2,481 01
Library extension,	–	199 43	–	–	–	–	–	–	199 43
M. A. C. Improvement Association,	21 35	110 85	–	–	–	–	–	45	132 65
Pomology,	485 88	416 85	–	–	–	–	–	–	902 73
Poultry convention,	64 42	264 50	–	–	–	–	–	–	328 92
Poultry husbandry,	103 15	29 50	–	–	–	–	–	–	132 65
Physical education,	357 74	70 00	–	–	–	–	–	–	427 74
Summer school,	220 81	–	–	225 98	68 50	$2,259 48	–	542 01	3,316 78
Ten weeks' school,	36 17	–	$47 15	253 96	2 70	1,538 86	–	63 32	1,942 16
Tree warden's school,	148 07	–	–	–	–	–	–	79 73	127 80
	$9,361 54	$6,883 52	$47 15	$1,364 19	$2,561 38	$3,798 34	$28,614 13	$3,474 51	$56,104 76

Special Appropriations.

Name of Appropriation.	Date made.	Amount of Apportionment.	Amount previously expended.	Amount expended during Fiscal Year.	Amount expended to Date.	Amount received from State Treasurer.	Balance on Hand with State Treasurer.
Sewers,	1912	$10,000 00	$9,240 55	$749 45	$10,000 00	$10,000 00	–
Miscellaneous improvements and repairs,	1913	26,000 00	16,550 55	9,449 45	26,000 00	26,000 00	–
Addition to French Hall,	1913	35,000 00	4,753 86	29,966 37	34,720 23	34,720 23	$279 77
Sewers,	1914	9,200 00	–	–	–	9,200 00	–
Hospital,	1913	15,000 00	–	1,947 52	1,947 52	1,947 52	13,852 48
Agricultural building,	1914	210,000 00	–	16,194 75	16,194 75	16,194 75	193,805 25
		$305,200 00	$30,554 96	$58,307 54	$87,862 50	$98,062 50	$207,937 50

Inventory — Real Estate.

Land (Estimated Value).

Baker place,	$2,500 00
Bangs place,	2,350 00
Clark place,	4,500 00
College farm,	37,000 00
Cranberry land,	11,025 00
Harlow farm,	3,284 63
Kellogg farm,	5,868 45
Louisa Baker place,	5,636 91
Old creamery place,	1,000 00
Pelham quarry,	500 00
Westcott place,	2,250 00
Allen place,	500 00
Charmbury place,	450 00
Loomis place,	415 00
Hawley & Brown place,	675 00
Newell farm,	2,800 00
	$80,754 99

College Buildings (Estimated Value).

Apiary,	$3,000 00
Animal husbandry building,	10,000 00
Chemical laboratory,	8,000 00
Clark hall,	67,500 00
Cold-storage laboratory,	12,000 00
Dairy building,	75,000 00
Dairy barn and storage,	30,000 00
Dining hall,	60,000 00
Drill hall and gun shed,	10,000 00
Durfee range and glass houses, old,	10,000 00
Durfee range and glass houses, new,	15,000 00
Entomology building,	80,000 00
Farm bungalow,	2,100 00
Farmhouse,	2,500 00
French Hall,	50,000 00
Horse barn,	5,000 00
Horticultural barn,	2,500 00
Horticultural tool shed,	2,000 00
Machinery barn,	4,000 00
Mathematical building,	6,000 00
North dormitory,	25,000 00
Physics laboratory,	5,500 00
Piggery,	3,000 00
Poultry breeding houses,	1,600 00
Poultry brooder house,	1,000 00
Poultry incubator cellar and demonstration building,	1,400 00
Poultry laboratory,	1,300 00
Poultry laying house,	1,800 00
Poultry mechanics and storage building,	1,900 00
Power plant and storage building,	18,500 00
President's house,	12,000 00

Quarantine barn,	$200 00
Sheep shed,	1,400 00
Small plant house, with vegetable cellar and cold grapery,	4,700 00
South dormitory,	35,000 00
Stone chapel,	30,000 00
Three houses on Stockbridge road,	5,000 00
Veterinary laboratory and stable,	23,500 00
Waiting station,	500 00
Wilder Hall,	37,500 00
Young stock barn,	6,500 00
	$671,900 00

College Equipment (Estimated Value).

Administrative division: —	
Dean's office,	$606 55
President's office,	1,548 00
Registrar's office,	861 00
Treasurer's office,	2,458 41
Agricultural division: —	
Agronomy,	1,598 14
Animal husbandry,	913 47
Dairy,	11,904 89
Farm administration,	1,158 34
Farm department,	35,199 89
Poultry,	3,752 59
Rural engineering,	199 49
Dining hall,	6,305 48
Extension,	6,340 53
General science: —	
Apiary,	1,691 34
Botanical,	9,818 63
Chemical,	12,298 05
Entomology,	6,406 18
Microbiology,	4,585 75
Mathematics,	2,543 70
History and political science,	20 75
Physics,	3,905 77
Veterinary,	9,361 40
Zoölogical laboratory,	9,449 52
Zoölogical museum,	6,511 05
Graduate school,	78 28
Horticultural division: —	
Floriculture,	6,989 72
Forestry,	1,546 57
General horticulture,	8,830 50
Grounds,	760 47
Landscape gardening,	5,071 21
Market gardening,	1,144 33
Pomology,	4,797 62
Humanities, division of: —	
Economics and sociology,	97 87
Language and literature,	248 15
Library,	77,795 85
Military,	1,492 42

Operating and maintenance: —		
College supply,		$610 41
Fire apparatus,		1,673 80
General maintenance,		85,951 53
Equipment,	$77,857 10	
Carpentry and masonry supplies,	2,748 62	
Electrical supplies,	1,408 89	
Heating and plumbing supplies,	3,192 40	
Painting supplies,	744 52	
Janitors' supplies,		368 92
Sewer line,		10,000 00
Water mains,		10,545 39
Physical education,		2,729 98
Rural social science: —		
Agricultural economics.		350 00
Agricultural education,		856 94
Rural social service,		101 75
Textbooks,		565 31
Trophy room,		1,647 10
		$363,693 04

Experiment Station Buildings (Estimated Value).

Agricultural laboratory,	$15,000 00
Agricultural barns,	5,000 00
Agricultural farmhouse,	1,500 00
Agricultural glass house,	500 00
Cranberry buildings,	2,800 00
Plant and animal chemistry laboratory,	30,000 00
Plant and animal chemistry barns,	4,000 00
Plant and animal chemistry dairy,	2,000 00
Six poultry houses,	600 00
Entomological laboratory and glass house,	850 00
	$62,250 00

Experiment Station Equipment (Estimated Value).

Agricultural laboratory,	$6,406 70
Botanical laboratory,	5,879 40
Chemical laboratory,	17,304 08
Cranberry station,	3,075 74
Director's office,	4,313 61
Entomological laboratory,	24,881 28
Horticultural laboratory,	2,006 00
Meteorology laboratory,	1,010 00
Poultry department,	2,242 35
Treasurer's office,	766 50
Veterinary laboratory,	150 00
	$68,035 66

Inventory Summary.

Land,	$80,754 99
College buildings,	671,900 00
College equipment,	363,693 04
Experiment station buildings,	62,273 00
Experiment station equipment,	68,035 66
	$1,246,656 69

Students' Trust Fund Accounts.

	Disbursements for Year ending Nov. 30, 1914.	Receipts for Year ending Nov. 30, 1914.	Balance on Hand.	Balance brought forward Dec. 1, 1913.
Athletic,	$10,737 45	$9,221 03	$789 27	$2,305 69
College signal,	2,381 75	2,206 81	241 01	415 95
Dining hall,	58,401 07	57,812 19	—365 37	223 51
Keys,	67 75	66 75	68 25	69 25
Students' deposits,	11,952 46	11,195 69	1,720 88	2,477 65
Social Union,	900 72	864 16	495 21	531 77
Textbooks,	4,630 85	4,896 68	732 05	466 22
Athletic field,	8,137 80	8,129 31	—8 49	–
Uniforms,	4,391 41	3,281 25	3,025 24	4,135 40
1913 index,	–	–	7 42	7 42
1914 index,	16 36	11 00	–	5 36
1915 index,	1,201 89	1,173 75	8 78	36 92
1916 index,	378 65	378 72	07	–
Totals,	$103,198 16	$99,237 34	$6,714 32	$10,675 14
Balance on hand Dec. 1, 1913,	–	10,675 14	–	–
Balance on hand Nov. 30, 1914,	6,714 32	–	–	–
	$109,912 48	$109,912 48	–	–

Detailed Statement of Dining Hall.

	Liabilities.	Resources.
Dec. 1, 1913, credit balance,	–	$223 51
Nov. 30, 1914, total disbursements,	$58,401 07	–
Nov. 30, 1914, outstanding bills,	2,410 25	–
Nov. 30, 1914, total collections,	–	57,812 19
Nov. 30, 1914, accounts outstanding,	–	235 40
Nov. 30, 1914, inventory,	–	2,883 71
Nov. 30, 1914, balance,	343 49	–
	$61,154 81	$61,154 81

Endowment Fund.[1]

	Principal.	Income.
United States grant (5 per cent.),	$219,000 00	$7,300 00
Commonwealth grant ($3\frac{1}{2}$ per cent.),	142,000 00	3,313 33
	–	$10,613 32

[1] This fund is in the hands of the State Treasurer, and the Massachusetts Agricultural College receives two-thirds of the income from the same.

Beneficiary Funds.

Burnham Emergency Fund.

	Market Value Dec. 1, 1914.	Par Value.	Income.
Two bonds American Telephone and Telegraph Company 4s, at $875,	$1,750 00	$2,000 00	$80 00
Two bonds Western Electric Company 5s, at $1,000,	2,000 00	2,000 00	100 00
	$3,750 00	$4,000 00	$180 00
Overdraft Dec. 1, 1913,	–	–	—39 45
Cash on hand Dec. 1, 1914,	–	–	$140 55

Library Fund.

Five bonds New York Central & Hudson River Railroad Company 4s, at $880,	$4,400 00	$5,000 00	$200 00
Five bonds Lake Shore & Michigan Southern Railroad Company 4s, at $900,	4,500 00	5,000 00	200 00
Two shares New York Central & Hudson River Railroad Company stock, at $88,	176 00	200 00	10 00
Amherst Savings Bank, deposit,	167 77	167 77	7 09
	$9,243 77	$10,367 77	$417 09
Nov. 28, 1914, transferred to college library account,	–	–	417 09

Special Funds.

Endowed Labor Fund (the Gift of a Friend of the College).

Two bonds American Telephone and Telegraph Company 4s, at $875,	$1,750 00	$2,000 00	$80 00
Two bonds, Lake Shore & Michigan Southern Railroad Company 4s, at $900,	1,800 00	2,000 00	80 00
One bond New York Central Railroad debenture 4s,	880 00	1,000 00	40 00
Amherst Savings Bank, deposit,	143 39	143 39	6 07
One bond Metropolitan Street Railway, Kansas City Company 5s, at	950 00	1,000 00	60 00
	–	$6,143 39	$266 07
Unexpended balance Dec. 1, 1913,	–	–	758 83
Cash on hand Dec. 1, 1914,	–	–	$1,024 90

Whiting Street Scholarship Fund.

One bond New York Central debenture 4s,	$880 00	$1,000 00	$40 00
Amherst Savings Bank, deposit,	271 64	271 64	11 51
	–	$1,271 64	$51 51
Unexpended balance Dec. 1, 1913,	–	–	84 65
Cash on hand Dec. 1, 1914,	–	–	$136 16

SPECIAL FUNDS — *Continued.*

Hills Fund.

	Market Value Dec. 1, 1914.	Par Value.	Income.
One bond American Telephone and Telegraph Company 4s, at	$875 00	$1,000 00	$40 00
One bond New York Central & Hudson River Railroad debenture 4s, at	880 00	1,000 00	40 00
One bond New York Central & Hudson River Railroad debenture 3½s, at	800 00	1,000 00	35 00
Two bonds Metropolitan Street Railway of Kansas City 5s, at $950,	1,900 00	2,000 00	120 00
Three bonds Pacific Telephone and Telegraph Company 5s, at $950,	2,850 00	3,000 00	150 00
One bond Western Electric Company 5s, at	950 00	1,000 00	50 00
Boston & Albany Railroad stocks, 3⅝ shares, at $180,	652 50	362 50	31 68
Amherst Savings Bank, deposit,	72 75	72 75	3 06
Electric Securities Company bonds, 1⁹/₅₀, at $1,000,	1,121 00	1,180 00	59 00
	$10,101 25	$10,615 25	$528 74
Unexpended balance Dec. 1, 1913,	–	–	544 34
	–	–	$1,073 08
Disbursements by the Botanical Department for fiscal year ending Nov. 30, 1914,	–	–	47 20
Cash on hand Dec. 1, 1914,	–	–	$1,025 88

Mary Robinson Fund.

Boston & Albany Railroad stock, ⅜ share, at $180,	$67 50	$38 00	$3 32
Electric Securities Company bonds, ⁴¹/₅₀ share, at $1,000,	779 00	820 00	41 00
	$846 50	$858 00	$44 32
Unexpended balance Dec. 1, 1913,	–	–	125 32
	–	–	$169 64
Disbursements for fiscal year ending Nov. 30, 1914,	–	–	13 75
Cash on hand Dec. 1, 1914,	–	–	$155 89

Grinnell Prize Fund.

Ten shares New York Central & Hudson River Railroad stock, at $82,	$820 00	$1,000 00	$50 00
Unexpended balance Dec. 1, 1913,	–	–	195 74
	–	–	$245 74
Disbursements for prizes,	–	–	50 00
Cash on hand Dec. 1, 1914,	–	–	$195 74

Gassett Scholarship Fund.

One bond New York Central & Hudson River Railroad debenture 4s,	$880 00	$1,000 00	$40 00
Amherst Savings Bank, deposit,	–	11 64	46
	–	$1,011 64	$40 46
Unexpended balance Dec. 1, 1913,	–	–	71 39
	–	–	$111 85
Disbursements for fiscal year ending Nov. 30, 1914,	–	–	10 00
Cash on hand Dec. 1, 1914,	–	–	$101 85

Special Funds — *Concluded.*

Massachusetts Agricultural College (Investment).

	Market Value Dec. 1, 1914.	Par Value.	Income.
One share New York Central & Hudson River Railroad stock,	$88 00	$100 00	$5 00
Unexpended balance Dec. 1, 1913,	–	–	65 45
Cash on hand Dec. 1, 1914,	–	–	$70 45

Danforth Keyes Bangs Fund.

		Market Value Dec. 1, 1914.	Par Value.	Income.
Two bonds Pacific Telephone and Telegraph Company 5s, at $950,		$1,900 00	$2,000 00	$100 00
Two bonds Union Electric Light and Power Company 5s, at $950,		1,900 00	2,000 00	100 00
Two bonds American Telephone and Telegraph Company 4s, at $875,		1,750 00	2,000 00	80 00
Interest from student loans,		–	–	29 86
		–	$6,000 00	$309 86
Unexpended balance Dec. 1, 1913,		–	–	380 35
		–	–	$690 21
Total loans made to students during fiscal year,	$1,688 00			
Cash received on account of student loans,	1,379 00			
Excess of loans made, over accounts paid by students,		. . .	. . .	309 00
Cash on hand Dec. 1, 1914,		. . .	. . .	$381 21

John C. Cutter Fund.

	Market Value Dec. 1, 1914.	Par Value.	Income.
One bond Pacific Telephone and Telegraph Company 5s,	$950 00	$1,000 00	$50 00
Unexpended balance Dec. 1, 1913,	–	–	13 12
	–	–	$63 12
Disbursements for fiscal year to date,	–	–	32 87
Cash on hand Dec. 1, 1914,	–	–	$30 25

Summary of Balances on Hand of the Income from Funds held in Trust by the Massachusetts Agricultural College.

Burnham emergency,	$140 55
Endowed labor fund,	1,024 90
Whiting Street scholarship fund,	136 16
Hills fund,	1,025 88
Mary Robinson fund,	155 89
Grinnell Prize fund,	195 74
Gassett scholarship fund,	101 85
Massachusetts Agricultural College investment fund,	70 45
Danforth Keyes Bangs fund,	381 21
John C. Cutter fund,	30 25
	$3,262 88

I hereby certify that I have this day examined the Massachusetts Agricultural College account, as reported by the treasurer, Fred C. Kenney, for the year ending Nov. 30, 1914. All bonds and investments are as represented in the treasurer's report. All disbursements are properly vouched for, and all cash balances are found to be correct.

CHARLES A. GLEASON,
Auditor.

History of Special Funds.

Burnham emergency fund: —	
A bequest of $5,000 from T. O. H. P. Burnham of Boston, made without any conditions. The trustees of the college directed that $1,000 of this fund should be used in the purchase of the Newell land and Goessmann library. The fund now shows an investment of	$4,000 00
Library fund: —	
The library of the college at the present time contains about 41,000 volumes. The income from the fund raised by the alumni and others is devoted to its increase, and additions are made from time to time as the needs of the different departments require. Dec. 27, 1883, William Knowlton gave $2,000; Jan. 1, 1894, Charles L. Flint gave $1,000; in 1887 Elizur Smith of Lee, Mass., gave $1,215. These were the largest bequests and now amount to	10,000 00
Endowed labor fund: —	
Gift of a friend of the college in 1901, income of which is to be used for the assistance of needy and deserving students,	5,000 00

Whiting Street scholarship: —
Gift of Whiting Street of Northampton, for no special purpose, but to be invested and the income used. This fund is now used exclusively for scholarship, . $1,000 00

Hills fund: —
Gift of Leonard M. and Henry F. Hills of Amherst, Mass., in 1867, to establish and maintain a botanic garden, ... 10,000 00

Mary Robinson fund: —
Gift of Miss Mary Robinson of Medfield, in 1874, for scholarship, ... 1,000 00

Grinnell prize fund: —
Gift of Hon. Wm. Claflin, to be known as the Grinnell agricultural prize, to be given to the two members of the graduating class who may pass the best oral and written examination in theory and practice of agriculture, given in honor of George B. Grinnell of New York, ... 1,000 00

Gassett scholarship fund: —
Gift of Henry Gassett of Boston, the income to be used for scholarship, ... 1,000 00

Massachusetts Agricultural College investment fund: —
Investment made by vote of trustees in 1893; to purchase one share of New York Central & Hudson River Railroad stock. The income from this fund has been allowed to accumulate, ... 100 00

Danforth Keyes Bangs fund: —
Gift of Louisa A. Baker, of Amherst, Mass., April 14, 1909, the income thereof to be used annually in aiding poor, industrious and deserving students to obtain an education in said college, ... 6,000 00

John C. Cutter fund: —
Gift of Dr. John C. Cutter, of Worcester, Mass., an alumnus of the college, who died in August, 1909, to be invested by the trustees, and the income to be annually used for the purchase of books on hygiene, ... 1,000 00

$41,000 00

Prizes.

Special prize, given by the Western Alumni Association to that member of the sophomore class who during his first two years has shown the greatest improvement in scholarship, character and example, ... $25 00

Animal husbandry. The F. Lothrup Ames prize, given by F. Lothrup Ames, Langwater Farms, North Easton, Mass., consisting of $150 a year, offered for a period of five years, to be given to the three students standing highest in the work of advanced live stock judging, and to be used in defraying their expenses incurred by participation in the students' judging contest at the National Dairy Show, Chicago. Given in May, 1912, available first in autumn of 1912, and for the four succeeding years, .	$150 00
Entomology. Special prize in entomology, given by Prof. H. T. Fernald of the Department of Entomology to that member of the class taking Entomology 2, who presents the best collection of insects, ...	5 00
	$180 00

FRED C. KENNEY,
Treasurer.

THE M. A. C. BULLETIN
AMHERST, MASS.

Vol. VII. No. I. For January, 1915

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CATALOGUE

OF THE

Massachusetts Agricultural College,

1914-1915.

Fifty-second Annual Report.

Part II.

BOSTON:
WRIGHT & POTTER PRINTING CO., STATE PRINTERS,
32 DERNE STREET.
1915.

Without excluding other scientific and classical studies, and including military tactics, to teach such branches of learning as are related to agriculture and the mechanic arts in such manner as the legislatures of the states may respectively prescribe, in order to promote the liberal and practical education of the industrial classes in the several pursuits and professions of life. — *Act of Congress, July 2, 1862.*

MASSACHUSETTS AGRICULTURAL COLLEGE,

AMHERST.

CATALOGUE, 1914-1915.

BOSTON:
WRIGHT & POTTER PRINTING CO., STATE PRINTERS,
32 DERNE STREET.
1915.

Approved by
The State Board of Publication.

The Massachusetts Agricultural College.

This issue of the catalogue represents the status of the college for the current college year, with provisional announcement of courses of study and other matters for the year to follow. Additional announcements are made in a supplementary bulletin, published in the spring.

The college reserves, for itself and its departments, the right to withdraw or change the announcements made in its catalogue. Special publication will be made should it become necessary on account of important changes.

Calendar.

1915-16.

Regular Courses.

1915.

January 4, Monday, 1 P.M.,	Winter recess ends; regular schedule of classes.
January 22, Friday, 8 A.M.,	Semester examinations begin.
February 1, Monday, 1 P.M.,	Second semester begins; regular schedule of classes.
February 22, Monday forenoon,	Half holiday, Washington's Birthday.
March 26, Friday, 5 P.M.,	Spring recess begins.
April 5, Monday, 1 P.M.,	Spring recess ends; regular schedule of classes.
April 19, Monday forenoon,	Half holiday, Patriots' Day.
May 31, Monday,	Holiday, observance of Memorial Day.
June 1, Tuesday, 8 A.M.,	Senior and junior examinations begin.
June 5, Saturday, 8 A.M.,	Sophomore and freshman examinations begin.
June 12–16, Saturday–Wednesday,	Commencement.
June 17–19, Thursday–Saturday,	Entrance examinations.
September 8–11, Wednesday–Saturday,	Entrance examinations.
September 15, Wednesday, 1.30 P.M.,	First semester begins; chapel.
October 12, Tuesday forenoon,	Half holiday, Columbus Day.
November 24, Wednesday, 12 M.,	Thanksgiving recess begins.
November 29, Monday, 1 P.M.,	Thanksgiving recess ends; regular schedule of classes.
December 17, Friday, 5 P.M.,	Winter recess begins.

1916.

January 3, Monday, 1 P.M.,	Winter recess ends; regular schedule of classes.
January 28, Friday, 8 A.M.,	Semester examinations begin.
February 7, Monday, 1 P.M.,	Second semester begins; regular schedule of classes.
February 22, Tuesday forenoon,	Half holiday, Washington's Birthday.
March 24, Friday, 5 P.M.,	Spring recess begins.
April 3, Monday, 1 P.M.,	Spring recess ends; regular schedule of classes.
April 19, Wednesday forenoon,	Half holiday, Patriots' Day.
May 30, Tuesday,	Holiday, Memorial Day.
June 5, Monday, 8 A.M.,	Senior and junior examinations begin.
June 10, Saturday, 8 A.M.,	Sophomore and freshman examinations begin.
June 17–21, Saturday–Wednesday,	Commencement.
June 22–24, Thursday–Saturday,	Entrance examinations.

Massachusetts Agricultural College.

History. — The Massachusetts Agricultural College was among the first of those organized under the national land grant act of 1862. This act granted public lands to the several States and Territories, the funds realized from the sale of which should be used to establish colleges of agriculture and mechanic arts; the bill was framed by the late Senator Justin Smith Morrill of Vermont. The Legislature of Massachusetts has granted money for the erection of nearly all the buildings now on the grounds, and makes annual appropriations for the maintenance of the college.

The college was incorporated in 1863, and on the 2d of October, 1867, was formally opened to its first class of students. At that time four buildings had been erected, and there were four regular instructors employed by the institution. In 1882 the State located its agricultural experiment station on the grounds of the college. Later, after the federal law was passed granting financial aid to experiment stations, the Massachusetts Agricultural Experiment Station was consolidated with the federal station, and subsequently the whole was incorporated with the college.

Courses. — The college offers an education without tuition fee to any student who is a resident of Massachusetts and who meets the requirements for admission. Women are admitted on the same basis as are men. Students who are not residents of Massachusetts are required to pay a nominal tuition fee. The four-years[1] course leads to the degree of bachelor of science, and the graduate school offers advanced courses leading to the degrees of master of science, doctor of philosophy and master of agriculture. The winter school of ten weeks, for admission to which no scholastic requirements are made, is held each winter, beginning early in January. There are other short courses at the college, such as the beekeepers' course and summer school. Various forms of extension teaching are carried on away from the college, such as correspondence courses, traveling schools, educational exhibits, lecture courses, demonstrations, and circulating libraries.

Purpose of the College. — The chief purpose of the college is to prepare men and women for the agricultural vocations. In this statement the term "agricultural vocations" is used in its broadest sense. Courses are offered which give efficient training in various agricultural pursuits, such as general farming, dairying, management of estates, poultry husbandry, fruit growing, market gardening, landscape gardening and forestry. Students are also fitted for positions in institutions designed for investigation in many sciences underlying the great agricultural industry, for teaching in agricultural col-

[1] Twenty-seven teaching departments offer instruction in agriculture, horticulture, sciences, the humanities and rural social science. A system of major courses permits a student to elect major work in 1 of 15 departments, specializing in that and allied subjects for a period of two years.

leges and high schools, for scientific experts in chemistry, entomology, botany and microbiology and for business operations having connection with practical agriculture.

Though the agricultural vocations are thus the chief concern of the college, students also find the course one that fits them admirably for pursuits in which the sciences, particularly chemistry, botany and zoölogy, are an essential preparation. Still other students find the course a desirable education, without regard to future occupation. The course of study is designed to give a student a general college education, and in addition to make it possible for him to specialize in any department in which a major course is offered.

Location and Equipment. — The agricultural college is located in the town of Amherst. The grounds comprise more than 600 acres, lying about a mile north of the village center. The equipment of the college, both in buildings and facilities for instruction, is excellent. Amherst is about 98 miles from Boston, and may be reached over the Central Massachusetts division of the Boston & Maine Railroad, or by way of the Central Vermont Railroad. Electric car lines connect Amherst with Northampton, Holyoke and Springfield.

The Massachusetts Agricultural Experiment Station.

Massachusetts provided for the establishment of an agricultural experiment station in 1882. This station, though on the college grounds and supported by the State, was then without organic connection with the college. Under an act of Congress, passed in 1887, an agricultural experiment station was established as a department of the college, and was supported by the general government. For a time, therefore, Massachusetts had two experiment stations at the college. In 1894 these were combined, and the station reorganized as a department of the college. It is now supported by funds from both the State and the general government. In 1906 the general government largely increased its support of experiment stations, on condition, however, that the money thus provided should be used only for research. The station now receives about one-third of its support from the State.

The station is under the direct supervision of the Board of Trustees. The chief officer is the director, who is responsible to the president and to a committee of the Board. The station is organized into a number of departments, all co-operating toward the betterment of agriculture. In most cases the heads of the station departments are heads of corresponding departments in the college. The work of the station takes three directions; namely, control work, experimentation and investigation. The station publishes numerous bulletins and two annual reports, one scientific, the other for practical farmers and for general distribution. These publications, conveying information as to results of experiments, are free, and circulate extensively, the mailing list containing some 20,000 addresses.

THE CORPORATION.

MEMBERS OF THE CORPORATION.

	TERM EXPIRES
NATHANIEL I. BOWDITCH of Framingham,	1915
WILLIAM WHEELER of Concord,	1915
ARTHUR G. POLLARD of Lowell,	1916
CHARLES A. GLEASON of New Braintree,	1916
FRANK GERRETT of Greenfield,	1917
HAROLD L. FROST of Arlington,	1917
CHARLES H. PRESTON of Danvers,	1918
FRANK A. HOSMER of Amherst,	1918
DAVIS R. DEWEY of Cambridge,	1919
GEORGE P. O'DONNELL of Northampton,	1919
WILLIAM H. BOWKER of Concord,	1920
GEORGE H. ELLIS of West Newton,	1920
ELMER D. HOWE of Marlborough,	1921
EDMUND MORTIMER of Grafton,	1921

MEMBERS EX OFFICIO.

His Excellency Governor DAVID I. WALSH, *President of the Corporation.*
KENYON L. BUTTERFIELD, *President of the College.*
DAVID SNEDDEN, *State Commissioner of Education.*
WILFRID WHEELER, *Secretary of the State Board of Agriculture.*

OFFICERS OF THE CORPORATION.

His Excellency Governor DAVID I. WALSH of Boston, *President.*
CHARLES A. GLEASON of New Braintree, *Vice-President.*
WILFRID WHEELER of Concord, *Secretary.*
FRED C. KENNEY of Amherst, *Treasurer.*
CHARLES A. GLEASON of New Braintree, *Auditor.*

STANDING COMMITTEES OF THE CORPORATION.[1]

Committee on Finance.

CHARLES A. GLEASON, *Chairman.*
GEORGE H. ELLIS.
NATHANIEL I. BOWDITCH.
ARTHUR G. POLLARD.
FRANK A. HOSMER.
EDMUND MORTIMER.

Committee on Course of Study and Faculty.

WILLIAM WHEELER, *Chairman.*
WILLIAM H. BOWKER.
FRANK A. HOSMER.
DAVID SNEDDEN.
ELMER D. HOWE.
DAVIS R. DEWEY.
GEORGE P. O'DONNELL.

Committee on Farm.

NATHANIEL I. BOWDITCH, *Chairman.*
FRANK GERRETT.
CHARLES A. GLEASON.
GEORGE H. ELLIS.

[1] The president of the college is ex officio member and secretary of standing committees.

Committee on Horticulture.

Harold L. Frost, *Chairman.*
Davis R. Dewey.
Elmer D. Howe.
Wilfrid Wheeler.

Committee on Experiment Department.[1]

Charles H. Preston, *Chairman.*
Wilfrid Wheeler.
Arthur G. Pollard.
Harold L. Frost.
Edmund Mortimer.

Committee on Buildings and Arrangement of Grounds.

William H. Bowker, *Chairman.*
William Wheeler.
Frank Gerrett.
Charles H. Preston.
George P. O'Donnell.

Committee on Extension Service.

Elmer D. Howe, *Chairman.*
George H. Ellis.
Harold L. Frost.
Frank Gerrett.
Wilfrid Wheeler.
Edmund Mortimer.

Examining Committee of Overseers from the State Board of Agriculture.

John Bursley of West Barnstable.
Frank P. Newkirk of Easthampton.
William E. Patrick of Warren.
John J. Erwin of Wayland.
R. Henry Race of North Egremont.

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[1] The director of the experiment station is a member of the committee on experiment department, without vote.

Officers of the Institution.

[The names of the faculty are arranged in groups according to rank. Within these groups, the order depends upon seniority of service in the college, not upon seniority of appointment to the position now held.]

THE FACULTY.

Kenyon L. Butterfield, A.M., LL.D., ... President's House.
President of the College and Head of Division of Rural Social Science.

George F. Mills,[1] A.M., ... 21 Main Street.
Dean Emeritus.

Charles H. Fernald, Ph.D., ... 3 Hallock Street.
Honorary Director of the Graduate School.

Edward M. Lewis, A.M., ... 19 Lincoln Avenue.
Dean of the College and Professor of Languages and Literature.

Fred C. Kenney, ... Mount Pleasant.
Treasurer of the College.

William P. Brooks, Ph.D., ... 6 Farview Way.
Director of the Experiment Station and Lecturer on Soil Fertility.

William D. Hurd, M.Agr., ... 46 Amity Street.
Director of the Extension Service and Supervisor of Short Courses.

Charles E. Marshall, Ph.D., ... Sunset Avenue.
Director of the Graduate School and Professor of Microbiology.

Frank A. Waugh, M.Sc., ... Campus.
Head of Division of Horticulture and Professor of Landscape Gardening.

James A. Foord, M.Sc.Agr., ... Lincoln Avenue.
Head of Division of Agriculture and Professor of Farm Administration.

Robert J. Sprague, Ph.D., ... Mount Pleasant.
Head of Division of the Humanities and Professor of Economics and Sociology.

Joseph B. Lindsey, Ph.D., ... 47 Lincoln Avenue.
Goessmann Professor of Chemistry.

Charles Wellington, Ph.D., ... 34 Amity Street.
Professor of Chemistry.

James B. Paige, B.Sc., D.V.S., ... 42 Lincoln Avenue.
Professor of Veterinary Science.

George E. Stone,[2] Ph.D., ... Mount Pleasant.
Professor of Botany.

Philip B. Hasbrouck, B.Sc., ... 130 Pleasant Street.
Professor of Physics and Registrar of the College.

John E. Ostrander, A.M., C.E., ... 33 North Prospect Street.
Professor of Mathematics and Civil Engineering.

Henry T. Fernald, Ph.D., ... 44 Amity Street.
Professor of Entomology, Chairman of Division of Science.

George C. Martin, C.E., Captain 18th U. S. Infantry, ... Amherst House.
Professor of Military Science and Tactics.

William R. Hart, A.M., L.B., ... 97 Pleasant Street.
Professor of Agricultural Education.

Fred C. Sears, M.Sc., ... Mount Pleasant.
Professor of Pomology.

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[1] Dean Mills died Oct. 27, 1914.

[2] On leave of absence; Associate Professor Osmun acting as head of Department of Botany.

Joseph S. Chamberlain, Ph.D., ... Mount Pleasant.
Professor of Organic and Agricultural Chemistry.

William P. B. Lockwood, M.Sc., ... 7 East Pleasant Street.
Professor of Dairying.

John C. Graham, B.Sc.Agr., ... Lincoln Avenue.
Professor of Poultry Husbandry.

William D. Clark, A.B., M.F., ... 3 Mount Pleasant.
Professor of Forestry.

Sidney B. Haskell, B.Sc., ... North Amherst.
Associate Professor of Agronomy.

A. Vincent Osmun, M.Sc., ... 5 Kendrick Place.
Associate Professor of Botany.

Clarence E. Gordon, Ph.D., ... 38 Lincoln Avenue.
Associate Professor of Zoölogy and Geology.

Robert W. Neal, A.M., ... 8 Woodside Avenue.
Associate Professor of English.

Alexander E. Cance, Ph.D., ... 9 Fearing Street.
Associate Professor of Agricultural Economics and Supervisor of Agricultural Surveys.

—— ——, ... — —
Associate Professor of Rural Sociology.

Burton N. Gates, Ph.D., ... 42 Lincoln Avenue.
Associate Professor of Beekeeping.

John A. McLean, A.B., B.Sc.Agr., ... Lincoln Block.
Associate Professor of Animal Husbandry.

G. Chester Crampton, Ph.D., ... 86 Pleasant Street.
Associate Professor of Entomology.

Charles A. Peters, Ph.D., ... South Sunset Avenue.
Associate Professor of Inorganic and Soil Chemistry.

George E. Gage, Ph.D., ... 27 Sunset Avenue.
Associate Professor of Animal Pathology.

Curry S. Hicks, B.Pd., ... 8 Allen Street.
Associate Professor of Physical Education and Hygiene.

Ernest Anderson, Ph.D., ... 3 Phillips Street.
Associate Professor of General and Physical Chemistry.

F. H. Hesselink van Suchtelen, Ph.D., ... 73 Pleasant Street.
Associate Professor of Microbiology.

Arno H. Nehrling, ... 24 Pleasant Street.
Associate Professor of Floriculture.

Christian I. Gunness, B.Sc., ... 4 Chestnut Street.
Associate Professor of Rural Engineering.

Edgar L. Ashley, A.M., ... 24 Pleasant Street.
Assistant Professor of German.

Alexander A. Mackimmie, A.M., ... North Amherst.
Assistant Professor of French.

Ralph J. Watts, B.Sc., ... 10 Nutting Avenue.
Secretary of the College.

Charles R. Green, B.Agr., ... Mount Pleasant.
Librarian.

C. Robert Duncan, B.Sc., C.E., ... 31 North Prospect Street.
Assistant Professor of Mathematics.

Arthur K. Harrison, ... 8 Allen Street.
Assistant Professor of Landscape Gardening.

Elvin L. Quaife, B.Sc.Agr., ... 4 Nutting Avenue.
Assistant Professor of Animal Husbandry.

William L. Machmer, A.M., M.E., ... 3 Kendrick Place.
Assistant Professor of Mathematics.

Henry E. Smith, A.M., ... 24 Pleasant Street.
Assistant Professor of English.

Walter W. Chenoweth, A.B., M.Sc., ... North Amherst.
Assistant Professor of Pomology.

Elmer E. McDonald, B.Sc., ... 24 Pleasant Street.
Assistant Professor of Agronomy.

Harold E. Robbins, B.Sc., A.M., ... 12 Nutting Avenue.
Assistant Professor of Physics.

Frank W. Rane, M.F., ... Boston.
Lecturer in Forestry.
Helena T. Goessmann, M.Ph., ... 13 Main Street.
Instructor in English.
William L. Harmount, A.B., ... 86 Pleasant Street.
Instructor in French.
Arthur N. Julian, A.B., ... Farview Way.
Instructor in German.
Frederick A. McLaughlin, B.Sc., ... Clark Hall.
Instructor in Botany.
Samuel Coons, ... 56 Pleasant Street.
Instructor in Dairying.
Walter E. Prince, Ph.B., A.M., ... 25 Pleasant Street.
Instructor in English and Public Speaking.
Robert H. Bogue, B.Sc., ... North Amherst.
Instructor in Chemistry.
—— ——[1] . . . . – –
Instructor in Market Gardening.
Frank N. Blanchard, A.B., ... 31 North Prospect Street.
Instructor in Zoölogy and Geology.
Loyal F. Payne, B.Sc., ... 5 School Street.
Instructor in Poultry Husbandry.
Frank P. Rand, A.B., ... 24 Pleasant Street.
Instructor in English.
Raymond G. Smith, B.Sc., ... Clark Hall.
Assistant in Botany.
William J. Fitzmaurice, ... – –
Assistant in Physical Education.
Harold M. Gore, B.Sc., ... 8 Allen Street.
Assistant in Physical Education.
Burt A. Hazeltine, B.Sc., ... 4 North Prospect Street.
Assistant in Mathematics.
Harold E. Baldinger, B.Sc., ... 2 McClellan Street.
Assistant in Dairying.
William S. Regan, B.Sc., ... 6 Allen Street.
Assistant in Entomology.

Graduate Assistants.

Roy C. Avery,[2] B.Sc., ... 17 Phillips Street.
Department of Microbiology.
Charles G. Baird, A.M., ... 31 North Prospect Street.
Department of Rural Sociology.
Ernest L. Davies,[3] B.Sc., ... 75 Pleasant Street.
Department of Microbiology.
Franklin C. Gurley, B.Sc., ... 81 Pleasant Street.
Department of Chemistry.
Arao Itano, B.Sc., ... 73 Pleasant Street.
Department of Microbiology.
Russell F. Lund, A.B., ... Pine Heights.
Department of Rural Sociology.
James F. Martin, M.Sc., ... 19 South East Street.
Department of Entomology.
Frederick G. Merkle, B.Sc., ... East Street.
Department of Agronomy.
Stuart P. Miller, B.Sc., ... 81 Pleasant Street.
Department of Chemistry.
Carl F. Oberhelman, B.Sc., ... 81 Pleasant Street.
Department of Landscape Gardening.
Harold A. Robinson, B.Sc., ... 6 Allen Street.
Department of Chemistry.

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[1] Position filled temporarily by Mr. Harold F. Tompson.
[2] From Nov. 14, 1914.
[3] Resigned, to take effect Nov. 14, 1914.

Paul Serex, Jr., B.Sc., ... Chemical Laboratory.
Department of Chemistry.
Carl J. Strand, A.M., ... 75 Pleasant Street.
Department of Agricultural Economics.
Arthur S. Thurston, B.Sc., ... 92 Pleasant Street.
Department of Floriculture.
Warren F. Whittier, A.B., ... Mount Pleasant.
Department of Animal Husbandry.

THE EXPERIMENT STATION STAFF.

Administration.

William P. Brooks, Ph.D., ... 6 Farview Way.
Director.
Joseph B. Lindsey, Ph.D., ... 47 Lincoln Avenue.
Vice-Director.
Fred C. Kenney, ... Mount Pleasant.
Treasurer.
Charles R. Green, B.Agr., ... Mount Pleasant.
Librarian.

Department of Agriculture.

William P. Brooks, Ph.D., ... 6 Farview Way.
Agriculturist.
Henry J. Franklin, Ph.D., ... Wareham.
In charge of Cranberry Investigation.
Edwin F. Gaskill, B.Sc., ... North Pleasant Street.
Assistant Agriculturist.

Department of Botany and Vegetable Pathology.

George E. Stone,[1] Ph.D., ... Mount Pleasant.
Botanist and Plant Pathologist.
George H. Chapman, M.Sc., ... 13 Fearing Street.
Assistant Botanist.
Orton L. Clark, B.Sc., ... Mount Pleasant.
Assistant Botanist.

Department of Entomology.

Henry T. Fernald, Ph.D., ... 44 Amity Street.
Entomologist.
Burton N. Gates, Ph.D., ... 42 Lincoln Avenue.
Apiarist.
Arthur I. Bourne, A.B., ... 12 East Pleasant Street.
Assistant Entomologist.

Department of Plant and Animal Chemistry.

Joseph B. Lindsey, Ph.D., ... 47 Lincoln Avenue.
Chemist.
Edward B. Holland, M.Sc., ... 28 North Prospect Street.
Associate Chemist, in charge of Research Division.
Fred W. Morse, M.Sc., ... 40 Pleasant Street.
Research Chemist.
Henri D. Haskins, B.Sc., ... 14 Amity Street.
In charge of Fertilizer Division.
Philip H. Smith, M.Sc., ... 102 Main Street.
In charge of Feed and Dairy Division.
Lewell S. Walker, B.Sc., ... 19 Phillips Street.
Assistant.
Rudolph W. Ruprecht, M.Sc., ... 32 North Prospect Street.
Assistant.

[1] On leave of absence; Associate Professor Osmun acting as head of Department of Botany.

Carlton P. Jones, M.Sc., ... 30 North Prospect Street.
Assistant.
Carlos L. Beals, B.Sc., ... Sunderland.
Assistant.
Walter S. Frost, B.Sc., ... 24 Pleasant Street.
Assistant.
James P. Buckley, Jr., ... 29 Lincoln Avenue.
Assistant.
James T. Howard, ... 154 Main Street.
Collector.
Harry L. Allen, ... 89 Main Street.
Assistant.
James R. Alcock, ... North Amherst.
Assistant.

Department of Horticulture.

Frank A. Waugh, M.Sc., ... Campus.
Horticulturist.
Fred C. Sears, M.Sc., ... Mount Pleasant.
Pomologist.
Jacob K. Shaw, Ph.D., ... 1 Allen Street.
Research Pomologist.
John B. Norton, B.Sc., ... 84 Pleasant Street.
Graduate Assistant.

Department of Meteorology.

John E. Ostrander, A.M., C.E., ... 33 North Prospect Street.
Meteorologist.

Department of Poultry Husbandry.

John C. Graham, B.Sc.Agr., ... Lincoln Avenue.
In charge of Department.
Hubert D. Goodale, Ph.D., ... North Amherst.
Research Biologist.

Department of Veterinary Science.

James B. Paige, B.Sc., D.V.S., ... 42 Lincoln Avenue.
Veterinarian.

THE EXTENSION SERVICE STAFF.

William D. Hurd, M.Agr., ... 46 Amity Street.
Director of the Extension Service and Supervisor of Short Courses.
Earnest D. Waid, B.Sc.Agr., ... 61 Amity Street.
Assistant Director.
Orion A. Morton, ... Lincoln Avenue.
Extension Professor of Agricultural Education.
Ezra L. Morgan, A.M., ... 2 Allen Street.
Extension Professor of Community Planning.
Laura Comstock, ... 84 Pleasant Street.
Extension Professor of Home Economics.
Richard H. Ferguson, B.Sc.Agr., ... 5 School Street.
Extension Professor of Agricultural Economics.
George F. E. Story, B.Sc., ... 10 Allen Street.
Extension Instructor in Animal Husbandry.
Ralph W. Rees, A.B., B.Sc., ... 24 Pleasant Street.
Extension Instructor in Pomology.
Herbert J. Baker, B.Sc., ... 24 Pleasant Street.
Extension Instructor in Farm Management.
Philip H. Elwood, Jr., B.Sc.Agr., ... 24 Pleasant Street.
Extension Instructor in Civic Improvement.
Allister F. McDougall, B.Sc., ... 24 Pleasant Street.
Extension Instructor in charge of Demonstration Auto Truck.

Erwin H. Forbush, ... 8 Nutting Avenue.
Supervisor of Correspondence Courses.
Ethel H. Nash, ... 16 Nutting Avenue.
Extension Instructor in Agricultural Education.
Harriet J. Hopkins, B.Sc., ... 79 Pleasant Street.
Extension Instructor in Home Economics.
Benjamin W. Ellis, B.Sc., ... 24 Pleasant Street.
Extension Instructor in Farm Demonstration.
Lawrence B. Boston,[1] . . . . Sandwich.
Agricultural Adviser, Barnstable County.
John A. Scheuerle,[1] . . . . Springfield.
Secretary, Hampden County Improvement League.

THE CLERICAL STAFF.

Clarissa G. Babcock, B.Sc., ... 77 South Pleasant Street.
Library Assistant.
Frances C. Boynton, A.B., ... 44 Triangle Street.
Clerk, Department of Farm Administration.
Mary E. Caldwell, ... Draper Hall.
Cashier.
Mabel R. Case, A.B., ... 9 Phillips Street.
First Clerk, Extension Service.
Ada M. Chandler, A.B., ... 3 Fearing Street.
Cataloguer, Library.
Lena V. Chapman, ... 77 South Pleasant Street.
Library Assistant.
Bertha E. Christiansen, A.B., ... 25 Pleasant Street.
Assistant to the Dean.
Lucia G. Church, ... North Amherst.
First Clerk, Experiment Station.
Jessie V. Crocker, ... Sunderland.
Clerk, Department of Botany.
Marion S. Donaldson, B.Sc., ... 9 Phillips Street.
Stenographer, Department of Agricultural Education.
Lina E. Fisher, ... 28 Pleasant Street.
Stenographer, Department of Chemistry.
Grace E. Gailond, ... 28 Pleasant Street.
Stenographer, Experiment Station.
Alice M. Gilbert, ... Draper Hall.
Clerk, Department of Dairying.
Lillian M. Gelinas, ... 77 Pleasant Street.
Clerk, President's Office.
Hannah M. Griffin, A.B., ... 9 Phillips Street.
Clerk, Department of Farm Administration.
Cora B. Grover, ... North Amherst.
Clerk, Extension Service.
Marion Guertin, ... 20 Pleasant Street.
Stenographer, Department of Beekeeping.
Mary E. Horton, ... 15 Fearing Street.
Clerk, President's Office.
Esther L. Houghton, A.B., ... Draper Hall.
Clerk, Department of Microbiology and Division of the Humanities.
Alice M. Howard, ... North Amherst.
First Clerk, Experiment Station.
Lorian P. Jefferson, A.M., ... 84 Pleasant Street.
Expert Secretary, Division of Rural Social Science.
Rebecca L. Mellor, ... 7 Northampton Road.
Clerk, Experiment Station.
Fay L. Milton, ... Draper Hall.
Clerk, Department of Poultry Husbandry.

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[1] Gives part-time service to the Massachusetts Agricultural College.

Nell C. Milton, ... Draper Hall.
Stenographer, Division of Rural Social Science.
Elizabeth E. Mooney,[1] . . . . Northampton.
Stenographer, Department of Poultry Husbandry.
Gladys P. Moore, ... – –
Stenographer, Treasurer's Office.
Bridie E. O'Donnell, ... Hadley.
Clerk, Department of Entomology.
Ina M. Paige, ... Draper Hall.
Stenographer, Extension Service.
Helen C. Pomeroy, ... 17 Pleasant Street.
Stenographer, Division of Horticulture.
Luther R. Putney, ... Lincoln Avenue.
Clerk, Treasurer's Office.
Gladys E. Russell, A.B., ... 9 Phillips Street.
Clerk, Division of Horticulture.
Edna M. Sanders, ... Hadley.
Bookkeeper, Treasurer's Office.
Elsa Slattery, ... Northampton.
Stenographer, Extension Service.
Dorothy F. Smith, ... Draper Hall.
Clerk, Division of Horticulture.
Harriet C. Stevenson,[1] . . . . Woodside Avenue.
Stenographer, Department of Agricultural Economics.
Olive M. Turner, B.Sc., ... 22 Spaulding Street.
Clerk, Registrar's Office.
Henrietta L. Webster, ... Draper Hall.
First Clerk, Treasurer's Office.
Aurelia B. Wentworth, ... South Amherst.
Stenographer, Division of Agriculture.

STAFF OF OPERATING AND MAINTENANCE.

John J. Barber, ... Campus.
Farm Superintendent.
John L. Byard, ... 21 Pleasant Street.
Superintendent of the Apiary.
William Chesley, ... Draper Hall.
Steward of the Dining Hall.
Lawrence S. Dickinson, B.Sc., ... 2 Farview Way.
Foreman of Grounds.
Clarence A. Jewett, ... 112 Pleasant Street.
Superintendent of Buildings.
John J. Lee, ... East Pleasant Street.
Assistant to the Military Detail.
Percy C. Schroyer, B.Sc., ... 6 Phillips Street.
Assistant Engineer.
Newton Wallace, ... Campus.
Electrician.
James Whiting, ... 16 Hallock Street.
Foreman, Department of Floriculture.

[1] On part time.

Standing Committees of the Faculty.[1]

1914-15.

Catalogue and Other Publications.

Associate Professor Neal.
Assistant Professor Smith.
Assistant Professor Robbins.
Secretary Watts.

Commencement.

Professor Paige.
Treasurer Kenney.
Captain Martin.
Professor Lockwood.
Associate Professor Peters.
Associate Professor Nehrling.
Assistant Professor Duncan.
Secretary Watts.

Course of Study.

President Butterfield.
Professor Hart.
Professor Waugh.
Professor Foord.
Professor Sprague.
Professor Fernald.
Professor Ostrander.
Professor Marshall.
Professor Chamberlain.
Associate Professor Cance.
Assistant Professor Chenoweth.

Discipline (Advisory).

Dean Lewis.
Professor Hasbrouck.
Associate Professor Hicks.
Assistant Professor Mackimmie.
Assistant Professor Machmer.

Employment.

Professor Sears.
Dean Lewis.
Treasurer Kenney.
Associate Professor Haskell.

Entrance Examinations and Admission.

Professor Hasbrouck.
Professor Graham.
Associate Professor Osmun.
Assistant Professor Ashley.
Assistant Professor Machmer.
Mr. Rand.

[1] The president of the college is ex officio member of each standing committee.

Health and Sanitation.

Professor Marshall.
Treasurer Kenney.
Captain Martin.
Professor Lockwood.
Associate Professor Hicks.
Miss Comstock.

Library.

Professor Stone.
Professor Marshall.
Professor Wellington.
Professor Sprague.
Mr. Green.

Schedule.

Professor Lockwood.
Associate Professor Peters.
Assistant Professor Machmer.

Scholarship.

Associate Professor Gordon.
Dean Lewis.
Professor Hasbrouck.
Assistant Professor Mackimmie.
Assistant Professor Harrison.
Assistant Professor Machmer.

Student Life.

President Butterfield.
Dean Lewis.
Director Hurd.
Treasurer Kenney.
Professor Chamberlain.
Professor Sprague.
Professor Hart.
Professor Clark.
Associate Professor McLean.
Associate Professor Haskell.
Associate Professor Crampton.
Associate Professor Hicks.
Associate Professor Anderson.
Assistant Professor Mackimmie.
Assistant Professor Quaife.
Secretary Watts.
Assistant Professor Duncan.
Assistant Professor Machmer.
Mr. Prince.

Unclassified Students.

Professor Lockwood.
Professor Sears.
Associate Professor Peters.

Appointed to Athletic Board.

Dean Lewis.
Professor Hasbrouck.
Associate Professor Osmun.

The College.

Admission.

A. Application for Admission.

All correspondence concerning admission should be addressed to the registrar.

Every applicant for admission to the college must be at least sixteen years old, and must present to the registrar proper testimonials of good character. Such testimonials, whenever possible, should come from the principal of the school at which the applicant has prepared for college. Candidates who desire to present themselves for examination in any subjects must make application to the college for such privilege at least one month before examination is desired. Blanks for such application may be obtained by addressing the registrar of the college. All entrance credentials must be in the hands of the registrar before the applicant can matriculate.

B. Modes of Admission.

Students are admitted to the freshman class either upon certificate or upon examination. No *diploma* from a secondary school will be accepted.

Certificates. — Certificates will be received from those schools in New England which have been approved by the New England College Entrance Certificate Board. Principals of schools in New England who desire the certificate privilege should address the secretary of the Board, Professor Frank W. Nicolson, Wesleyan University, Middletown, Conn. Certificates from schools outside of New England will be received if those schools are on the approved list of the leading colleges of the section in which the school in question is located.

The credentials of the Board of Regents of the State of New York are accepted as satisfying the entrance requirements of this college when offered subject for subject.

Certificates must present not less than seven of the necessary fourteen credits in all. Those subjects lacking on certificate (except for the permitted number of conditions) must be made up at the time of the examinations for admission.

Blank forms for certification — sent to principals or school superintendents only — may be obtained on application to the registrar of the college.

Examinations. — The examination in each subject may be oral or written, or both. The standard required for passing an examination for admission is 65 per cent. Conditions to the amount of two units will be allowed.[1]

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[1] *Entrance with Condition in English.* — Under the rule permitting entrance conditions of not more than two units of the preparatory subjects, applicants may be admitted upon examination, with a condition in English, provided that they show, upon examination, preparation in work entitling them to a ranking of 60 or higher.

Students so admitted, must, to remove the condition, pass an examination covering the regular three-units requirement.

Entrance examination for admission to the Massachusetts Agricultural College will be held at the following centers: —

In June, ...	Amherst, Department of Physics building. Boston, College of Liberal Arts, Boston University. Worcester, Horticultural Hall.
In September, ...	Amherst, Department of Physics building.

Please note that September examinations are held in Amherst only.

Schedule for Entrance Examinations, June 17–19, inclusive, 1915. — The examinations in June will follow this schedule: —

First Day.

7.45 A.M.	Registration.[1]
8.00 A.M.	Plane geometry.
10.00 A.M.	Chemistry.
11.30 A.M.	Botany.
2.00 P.M.	Algebra.
3.30 P.M.	Physics.

Second Day.

8.00 A.M.	Required English.
11.00 A.M.	Solid geometry.
2.00 P.M.	History, required and elective.

Third Day.

8.00 A.M.	French, German, required and elective.
1.00 P.M.	Latin A and B and all one-half credit electives, except those already noted.

Schedule for Entrance Examinations in September. — In September, 1914, the examinations will be given September 8–11, inclusive, and will follow the order indicated below: —

First Day.

1.00 P.M.	Registration.
1.15–5.00 P.M.	Greek A and B.

Second Day.

8.00 A.M.	Plane geometry.
10.00 A.M.	Chemistry.
11.30 A.M.	Botany.
2.00 P.M.	Algebra.
3.30 P.M.	Physics.
4.30 P.M.	Elective English.

Third Day.

8.00 A.M.	Required English.
11.00 A.M.	Solid geometry, agriculture.
2.00 P.M.	History, required and elective.

Fourth Day.

8.00 A.M.	French, German, required and elective.
1.00 P.M.	Latin A and B and all one-half credit electives, except those already noted.

[1] Candidates who have no examination at the time set for registration may register at the time of their first examination should they so desire.

C. Requirements for Admission.

The requirements for admission are based on the completion of a four-years high school course, or its equivalent, and are stated in terms of units. The term unit means the equivalent of at least four recitations a week for a school year. **Neither more nor less credit will be given in any subject than is indicated in the table below.** Fourteen units must be offered for admission. In the list given below, *every subject in black-faced type is absolutely required and no substitution is allowed.* The subjects so typed total eight and one-half units. In addition to these points five and one-half more units must be chosen from the subjects printed in light-faced type. Not more than four half-credit units may be offered.

Agriculture,[1]	½ or 1
Botany,[2]	½ or 1
Chemistry,[2]	1
Algebra,	1½
Plane geometry,	1
Solid geometry,	½
Trigonometry,	½
Physics,[2]	1
Geology,[2]	½
Physiography,	½
Physiology,	½
Zoölogy,[2]	½
History[3] (Ancient; Medieval and Modern; English; General; United States and Civics), *any one,*	1[4]
English,	3
English (elective),[1]	1
Modern Language (elementary French or elementary German),	2
Elementary French,[5]	2
Elementary German,[5]	2
Intermediate French,	1
Advanced French,	1
Intermediate German,	1
Advanced German,	1
Greek A,[1]	2
Greek B,[1]	1
Latin A,	2
Latin B,	1
Commercial geography,[5]	½
Drawing,[6]	½
Manual training,[6]	½ or 1

PRESENTATION OF NOTE-BOOKS. — The keeping of a note-book is required as part of the preparation in those subjects indicated (see note 2, page 25).

Candidates presenting themselves for examination in such subjects must present at the same time the required note-book, properly certified by the principal. Candidates presenting such subjects on certificates should not present note-books; but their certificates must state that note-books have been satisfactorily completed.

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[1] Examination in September only.

[2] Note-book required as part of preparation will be credited as part of the examination.

[3] One must be offered for the required point, one, two or three others may be offered for elective points.

[4] For each offered.

[5] May be offered as elective if not offered to satisfy *required* points.

[6] On certificate only, no examination given.

D. Statement of Preparation Required for Admission.

Agriculture. — Owing to the wide divergence of the methods of teaching agriculture in the public schools, the student will be required to bring a statement from the principal of the amount and kinds of work accomplished and of the text-books used. The examination will be based somewhat upon this information; but it will call for not less than one-half year of creditable work of high school grade. **The examination in agriculture will be given in September only.**

Botany. — For one unit of credit in botany, the work outlined in the statement of requirements issued by the College Entrance Examination Board, or its equivalent, will be accepted. This work should occupy one school year and include laboratory and supplementary text-book study. For one-half unit of credit, work that covers the same ground but occupies half the time required for a full unit of credit will be accepted. These requirements are met by such texts as Steven's "Introduction to Botany" and Bergen and Davis's "Principles of Botany." A note-book containing neat, accurate drawings and descriptive records forms part of the requirement for either the half-unit or the one-unit credit, and this note-book must be presented by all applicants for admission upon examination in this subject. The careful preparation of an herbarium is recommended to all prospective students of this college, although the herbarium is not required.

Chemistry. — The entrance examination in chemistry will cover the work outlined by the College Entrance Examination Board as preparatory for college entrance. In general, this consists of a year of high school chemistry from such text-books as Newell's "Descriptive Chemistry" or Remsen's "Elements of Chemistry," with laboratory work on the general properties of the common elements, some of the experiments being quantitative. The keeping of a note-book is required.

Mathematics. — (*a*) *Required.* — Algebra: The four fundamental operations for rational algebraic expressions; factoring, determination of highest common factor and lowest common multiple by factoring; fractions, including complex fractions; ratio and proportion; linear equations, both numerical and literal, containing one or more unknown quantities; problems depending on linear equations; radicals, including the extraction of the square root of polynomials and numbers; exponents, including the fractional and negative; quadratic equations, both numerical and literal; simple cases of equations with one or more unknown quantities that can be solved by the methods of linear or quadratic equations; problems depending upon quadratic equations; the binomial theorem for positive integral exponents, the formulas for the *n*th term and the sum of the terms of arithmetic and geometric progressions, with applications.

Plane Geometry: The usual theorems and constructions of good text-books, including the general properties of plane rectilinear figures; the circle and the measurement of angles; similar polygons; areas; regular polygons and the measurement of the circle; the solution of numerous original exercises, including loci problems; applications to the mensuration of lines and plane surfaces.

(*b*) *Elective.* — Solid Geometry: The usual theorems and constructions of good text-books, including the relations of planes and lines in space; the properties and measurement of prisms, pyramids, cylinders and cones; the

sphere and spherical triangle; the solution of numerous original exercises, including loci problems; applications to the mensuration of surfaces and solids.

Plane Trigonometry: A knowledge of the definitions and relations of trigonometric functions and of circular measurements and angles; proofs of the principal formulas and the application of these formulas to the transformation of the trigonometric functions; solution of trigonometric equations, the theory and use of logarithms, and the solution of right and oblique triangles.

Physics. — To satisfy the entrance requirement in physics, the equivalent of at least one unit of work is required. This work must consist of both class-room work and laboratory practice. The work covered in the class-room should be equal to that outlined in Hall & Bergen's "Text-book of Physics" or Millikan & Gale; the laboratory work should represent at least thirty-five experiments involving careful measurements, with accurate recording of each in laboratory note-book. This note-book, certified by the instructor in the subject, must be submitted by each candidate presenting himself for examination in physics; credit for passing the subject will be given on laboratory notes and on the examination paper submitted. Candidates entering on certificate will not be required to present note-books, but the principal's certification must cover laboratory as well as class-room work.

Physiology. — Hough & Sedgwick's "The Human Mechanism;" Martin's "The Human Body; Briefer Course."

Zoölogy, Physiography, Geology. — The following suggestions are made concerning preparation for admission in the subjects named above: —

For physiography, Davis's "Elementary Physical Geography;" Gilbert & Brigham's "Introduction to Physical Geography." For zoölogy, text-books entitled "Animals" or "Animal Studies," by Jordan, Kellogg and Heath; Linville & Kelley's "A Text-book in General Zoölogy." For geology, A. P. Brigham's "A Text-book of Geology" or Tarr's "Elementary Geology."

Applicants for examination in zoölogy are *required* to present certified laboratory note-books; applicants for examination in the other subjects are *advised* to present note-books, if laboratory work has been done. Good note-books may be given credit for entrance. Examination in these subjects will be general, in recognition of the different methods of conducting courses; but students will be examined on the basis of the most thorough secondary school courses.

History. — The required unit must be offered in either ancient history, medieval and modern history, English history, general history, or United States history and civics. Either one, two or three elective units in any of the historical subjects here named may be offered, provided that no unit be offered in the same subject in which the required unit has been offered.

Preparation in history will be satisfactory if made in accordance with the recommendations of the committee of seven of the American Historical Association, as outlined by the College Entrance Examination Board. The examination will require comparisons and the use of judgment by the candidate rather than the mere use of memory, and it will presuppose the use of good text-books, collateral reading and practice in written work. Geographical knowledge may be tested by requiring the location of places and movements on outline maps.

To indicate in a general way the character of the text-book work expected, the texts of the following authors are suggested: Botsford, Morey or Myers,

in ancient history (to 814 A.D.); Adams, West or Myers, in medieval history; Montgomery, Larned or Cheyney, in English history; Myers or Fisher, in general history; Fiske, together with MacLaughlin or Montgomery in United States history and civics.

English. — For 1915–19 inclusive: —

The study of English in school has two main objects: (1) command of correct and clear English, spoken and written; (2) ability to read with accuracy, intelligence and appreciation.

Grammar and Composition. — The first object requires instruction in grammar and composition. English grammar should ordinarily be reviewed in the secondary school; and correct spelling and grammatical accuracy should be rigorously exacted in connection with all written work during the four years. The principles of English composition governing punctuation, the use of words, sentences and paragraphs should be thoroughly mastered; and practice in composition, oral as well as written, should extend throughout the secondary school period. Written exercises may well comprise letter-writing, narration, description and easy exposition and argument. It is advisable that subjects for this work be taken from the student's personal experience, general knowledge and studies other than English, as well as from his reading in literature. Finally, special instruction in language and composition should be accompanied by concerted effort of teachers in all branches to cultivate in the student the habit of using good English in his recitations and various exercises, whether oral or written.

Literature. — The second object is sought by means of two lists of books, headed, respectively, "Reading" and "Study," from which may be framed a progressive course in literature covering four years. In connection with both lists the student should be trained in reading aloud and encouraged to commit to memory some of the more notable passages both in verse and in prose. As an aid to literary appreciation, he is further advised to acquaint himself with the most important facts in the lives of the authors whose works he reads and with their place in literary history.

A. Reading. — The aim of this course is to foster in the student the habit of intelligent reading and to develop a taste for good literature by giving him a first-hand knowledge of some of its best specimens. He should read the books carefully, but his attention should not be so fixed upon details that he fails to appreciate the main purpose and charm of what he reads.

With a view to large freedom of choice, the books provided for reading are arranged in the following groups, from each of which at least two selections are to be made, except as otherwise provided under Group I.: —

Group I. Classics in Translation: The "Old Testament," comprising at least the chief narrative episodes in Genesis, Exodus, Joshua, Judges, Samuel, Kings and Daniel, together with the books of Ruth and Esther; the "Odyssey," with the omission, if desired, of books I., II., III., IV., V., XV., XVI., XVII.; the "Iliad," with the omission, if desired, of books XI., XIII., XIV., XV., XVII., XXI.; the "Æneid." The "Odyssey," "Iliad" and "Æneid" should be read in English translations of recognized literary excellence.

For any selection from group I. a selection from any other group may be substituted.

Group II. Shakspere: "Midsummer Night's Dream;" "Merchant of Venice;" "As You Like It;" "Twelfth Night;" "The Tempest;" "Romeo

and Juliet;" "King John;" "Richard II.;" "Richard III.;" "Henry V.;" "Coriolanus;" "Julius Cæsar;"[1] "Macbeth;"[1] "Hamlet."[1]

Group III. Prose Fiction: Malory's "Morte d'Arthur" (about 100 pages); Bunyan's "Pilgrim's Progress," Part I.; Swift's "Gulliver's Travels" (voyages to Lilliput and to Brobdingnag); Defoe's "Robinson Crusoe," Part I.; Goldsmith's "Vicar of Wakefield;" Frances Burney's "Evelina;" Scott's novels, any *one;* Jane Austen's novels, any *one;* Maria Edgeworth's "Castle Rackrent" or "The Absentee;" Dickens's novels, any *one;* Thackeray's novels, any *one;* George Eliot's novels, any *one;* Mrs. Gaskell's "Cranford;" Kingsley's "Westward Ho!" or "Hereward the Wake;" Reade's "The Cloister and the Hearth;" Blackmore's "Lorna Doone;" Hughes's "Tom Brown's School Days;" Stevenson's "Treasure Island" or "Kidnapped" or "Master of Ballantrae;" Cooper's novels, any *one;* Poe's "Selected Tales;" Hawthorne's "The House of the Seven Gables" or "Twice Told Tales" or "Mosses from an Old Manse;" a collection of short stories by various standard writers.

Group IV. Essays, Biography, etc.: Addison and Steele's "The Sir Roger de Coverley Papers" or selections from the "Tatler" and "Spectator" (about 200 pages); selections from Boswell's "Life of Johnson" (about 200 pages); Franklin's "Autobiography;" selections from Irving's "Sketch Book" (about 200 pages) or "Life of Goldsmith;" Southey's "Life of Nelson;" selections from Lamb's "Essays of Elia" (about 100 pages); selections from Lockhart's "Life of Scott" (about 200 pages); Thackeray's "Lectures on Swift, Addison and Steele in the English Humorists;" Macaulay: any one of the following essays: "Lord Clive," "Warren Hastings," "Milton," "Addison," "Goldsmith," "Frederic the Great," "Madame d'Arblay;" selections from Trevelyan's "Life of Macaulay" (about 200 pages); Ruskin's "Sesame and Lilies" or "Selections" (about 150 pages); Dana's "Two Years before the Mast;" Lincoln's "Selections," including at least the two inaugurals, the speeches in Independence Hall and at Gettysburg, the last public address, the letter to Horace Greeley, together with a brief memoir or estimate of Lincoln; Parkman's "The Oregon Trail;" Thoreau's "Walden;" Lowell's "Selected Essays" (about 150 pages); Holmes's "The Autocrat of the Breakfast Table;" Stevenson's "An Inland Voyage" and "Travels with a Donkey;" Huxley's "Autobiography" and selections from "Lay Sermons," including the addresses on "Improving Natural Knowledge," "A Liberal Education" and "A Piece of Chalk;" a collection of "Essays" by Bacon, Lamb, De Quincey, Hazlitt, Emerson and later writers; a collection of "Letters" by various standard writers.

Group V. Poetry: Palgrave's "Golden Treasury" (first series), books II. and III., with special attention to Dryden, Collins, Gray, Cowper and Burns; Palgrave's "Golden Treasury" (first series), Book IV., with special attention to Wordsworth, Keats and Shelley (if not chosen for study under B); Goldsmith's "The Traveller" and "The Deserted Village;" Pope's "The Rape of the Lock;" a collection of English and Scottish ballads, as, for example, some "Robin Hood" ballads, "The Battle of Otterburn," "King Estmere," "Young Beichan," "Bewick and Grahame," "Sir Patrick Spens" and a selection from later ballads; Coleridge's "The Ancient Mariner," "Christabel" and "Kubla Khan;" Byron's "Childe Harold," Canto III. or IV., and "The Prisoner of Chillon;" Scott's "The Lady of the Lake," or "Marmion;"

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[1] If not chosen for study under B.

Macaulay's "The Lays of Ancient Rome," "The Battle of Naseby," "The Armada," "Ivry;" Tennyson's "The Princess" or "Gareth and Lynette," "Lancelot and Elaine" and "The Passing of Arthur;" Browning's "Cavalier Tunes," "The Lost Leader," "How They Brought the Good News from Ghent to Aix," "Home Thoughts from Abroad," "Home Thoughts from the Sea," "Incident of the French Camp," "Hervé Riel," "Pheidippides," "My Last Duchess," "Up at a Villa — Down in the City," "The Italian in England," "The Patriot," "The Pied Piper," "De Gustibus," "Instans Tyrannus;" Arnold's "Sohrab and Rustum" and "The Forsaken Merman;" selections from American poetry, with special attention to Poe, Lowell, Longfellow and Whittier.

B. Study. — This part of the requirement is intended as a natural and logical continuation of the student's earlier reading, with greater stress laid upon form and style, the exact meaning of words and phrases, and the understanding of allusions. The books provided for study are arranged in four groups, from each of which one selection is to be made.

Group I. Drama: Shakspere's "Julius Cæsar," "Macbeth," "Hamlet."

Group II. Poetry: Milton's "L'Allegro," "Il Penseroso" and either "Comus" or "Lycidas;" Tennyson's "The Coming of Arthur," "The Holy Grail" and "The Passing of Arthur;" the selections from Wordsworth, Keats and Shelley in Book IV. of Palgrave's "Golden Treasury" (first series).

Group III. Oratory: Burke's "Speech on Conciliation with America;" Macaulay's "Speech on Copyright" and Lincoln's "Speech at Cooper Union;" Washington's "Farewell Address" and Webster's "First Bunker Hill Oration."

Group IV. Essays: Carlyle's "Essay on Burns," with a selection from Burns's "Poems;" Macaulay's "Life of Johnson;" Emerson's "Essay on Manners."

Examination. — However accurate in subject-matter, no paper will be considered satisfactory if seriously defective in punctuation, spelling or other essentials of good usage.

The examination will be divided into two parts, one of which will be on grammar and composition, and the other on literature.

In grammar and composition, the candidate may be asked specific questions upon the practical essentials of these studies, such as the relation of the various parts of a sentence to one another, the construction of individual words in a sentence of reasonable difficulty, and those good usages of modern English which one should know in distinction from current errors. The main test in composition will consist of one or more essays, developing a theme through several paragraphs; the subjects will be drawn from the books read, from the candidate's other studies and from his personal knowledge and experience quite apart from reading. For this purpose the examiner will provide several subjects, perhaps eight or ten, from which the candidate may make his own selections. He will not be expected to write more than four hundred words per hour.

The examination in literature will include: —

(*a*) General questions designed to test such a knowledge and appreciation of literature as may be gained by fulfilling the requirements defined under "A, Reading," above. The candidate will be required to submit a list of the books read in preparation for the examination, certified by the principal of the school in which he was prepared; but this list will not be made the basis of detailed questions.

(*b*) A test on the books prescribed for study, which will consist of questions upon their content, form and structure, and upon the meaning of such words, phrases and allusions as may be necessary to an understanding of the works and an appreciation of their salient qualities of style. General questions may also be asked concerning the lives of the authors, their works and the periods of literary history to which they belong.

The Massachusetts Agricultural College calls attention to the following recommendations of the national conference, which agree with its policy: —

1. That colleges so desiring may set an examination requiring no prescribed books, but testing the same general kind of preparation as that indicated in the foregoing requirements.

2. That individual colleges take such steps as may be found necessary to ascertain whether candidates for entrance possess an adequate equipment in oral English.

As rapidly as seems expedient the college will proceed in accordance with these recommendations. Schools wishing to present candidates prepared in conformity to the intent of the recommendations will have the co-operation of the college.

English, Elective. — To secure a fourth entrance credit in English, the applicant should do (*a*) the full equivalent of three years' work (required English), and also (*b*) the full equivalent of a fourth year's work. Applicants not certified with a fourth entrance credit will be examined, provided that the applicant, on or before June 1, notify the Department of English of his intention to take the examination, and supply thereafter the information needed by the department to prepare the examination questions. The information blanks will be forwarded by the Department of English upon receipt of the notice. (**The examination in English elective will be given in September only.**)

Subjects accepted. — The applicant may offer (*a*) any one of the subjects stated hereunder, or (*b*) any two of these subjects in combination.

(*a*) History of American literature.

(*b*) History of English literature (or lives of the great authors).

(*c*) Classics *other than those read to meet the three-credit requirement.*

(*d*) Advanced composition.

(*e*) History of the English language.

(*f*) Advanced high school grammar.

Advanced Standing in College. — Whether advanced standing shall be given applicants entering with a fourth credit in English will be determined by consideration of each case individually. Much weight is given to the ability of the student to express himself correctly and clearly, to think clearly, and to grasp the meaning of printed language. A special examination will be given in the opening week of college, notice of which will be posted on the English bulletin board, for freshmen who wish to apply for advanced standing.

Presentation of Note-books and Themes. — Applicants for examination, either for fourth-unit credit or for advanced standing, are advised to present the note-books, themes, etc., prepared by them in the preparatory school, as an aid toward determining their proficiency.

French. — Elementary: The necessary preparation for this examination is stated in the description of the two-year course in elementary French recommended by the Modern Language Association, contained in the definition of requirements of the College Entrance Examination Board.

Third and fourth year French (elective subjects for admission). — For a third credit unit in French as an elective subject for entrance, the work heretofore described by the College Entrance Examination Board as "intermediate" is expected. For a fourth credit unit, the work described as "advanced" is expected.

No examination for a third unit in French will be given unless the candidate has presented elementary French on certificate, or has written the examination in elementary French.

No examination for a fourth credit in French will be given unless the candidate has presented both elementary and intermediate French upon certificate, or has written the examination in both elementary and intermediate French.

German. — Elementary: The entrance requirements in German conform to those of the College Entrance Examination Board for elementary German (the standard two-year requirements).

Third and fourth year German (elective subjects for admission). — For a third credit unit in German as an elective subject for entrance, when required units have been offered in German, the work heretofore described by the College Entrance Examination Board as "intermediate" is expected. For a fourth credit unit, the work described as "advanced" is expected.

No examination for a third unit in German will be given unless the candidate has presented elementary German upon certificate, or has written the examination in elementary German.

No examination for a fourth credit in German will be given unless the candidate has presented both elementary and intermediate German upon certificate, or has written the examination for both elementary and intermediate German.

Greek. — Greek will receive credit as an elective requirement upon either examination or certification, as follows. (**The examination in Greek A and Greek B will be given in September only.**)

A. Two credit units will be allowed if satisfactory proficiency is shown (including grammar) in (*a*) the translation of a passage or passages taken from the first four books of Xenophon's "Anabasis," and (*b*) the translation of passages of Attic prose at sight.

B. A third credit unit will be allowed if, in addition to the above, satisfactory proficiency be shown in (*a*) the translation of a passage or passages from the first six books of Homer's "Iliad," and (*b*) translation of passages of Homer's "Iliad" at sight, with questions on the form and constructions of the passages.

Latin. — Latin will receive credit as an elective requirement upon either examination or certification, as follows: —

A. Two credit units will be allowed if satisfactory proficiency is shown (including grammar) in (*a*) the translation of a passage or passages taken from Cæsar's "Gallic War," covering at least four books, and (*b*) the translation of passages of Latin prose at sight.

B. A third credit unit will be allowed if, in addition to the above, satisfactory proficiency be shown in (*a*) the translation of a passage or passages selected from either books I. to VI. of Virgil's "Æneid," or six orations of Cicero, including those against Catiline; and (*b*) the translation into Latin prose of a passage of connected English narrative based on some portion of Cæsar's "Gallic War," books I. to IV.

Commercial Geography.[1] — Preparation should be made in a course equivalent to that laid down in Adams's "Commercial Geography," Trotter's "Geography of Commerce," or a similar work. (No examination given.)

Drawing.[1] — The applicant may offer either freehand or mechanical drawing or both. He must be able to make an accurate freehand sketch in either outline or light and shade, of the appearance of a group of geometric solids, and have a sufficient knowledge of perspective to enable him to draw correctly a simple geometric model from memory; or, if he present mechanical drawing, he must have working familiarity with drawing instruments, and be able to make an accurate inked working drawing, in orthographic projection, of some simple object. Emphasis is laid on facility in doing good freehand lettering. For a limitation of the work that may be presented, see "Manual Training." (No examination given.)

Manual Training.[1] — An entrance credit of one-half or one unit is allowed for manual training, on the presentation of a certificate from the principal of the school showing the scope and character of the applicant's work. The preparation may include mechanical drawing, working in wood, metals, leather, etc. When mechanical drawing is presented as a part of the work in manual training, no other credit for drawing will be allowed. No examination is given in this subject; applicants must present certificates to secure credit.

E. Admission to Advanced Standing.

Candidates for admission to advanced standing, in addition to meeting the regular entrance requirements, must also pass examinations in those subjects already pursued by the class they desire to enter. To meet this requirement, a student transferring to this college from another college or university of recognized standing must present the following credentials: —

1. A letter of honorable dismissal from the institution with which he has been connected.
2. A statement or certificate of his entrance record.
3. A statement from the proper officer showing a complete record of his work while in attendance.
4. A marked catalogue showing the courses pursued.

These credentials should be presented to the registrar. Applications will be judged wholly on their merits and the college may prescribe additional tests before accepting applicants or determining the standing to be granted them.

F. Other Information about Entrance.

1. The privileges of the college may be withdrawn from any student at any time if such action is deemed advisable. (It is immaterial whether the pupil has entered by certificate or by examination.)
2. The examination in each subject may be either oral or written, or both. The standard required for passing an entrance examination is 65 per cent.
3. Candidates must receive credit for twelve units out of the total number required for entrance, and will be conditioned in those subjects not passed. No candidate deficient in both algebra and plane geometry will be admitted.
4. Examinations for the removal of entrance conditions will be held as follows: (1) First entrance condition examination, in the week following

[1] On certificate only; no examination given.

the Thanksgiving recess. (2) Second entrance condition examination, in the sixteenth week of the first semester.

5. Credits for entrance requirements, whether gained by certificate or by examination, will hold good for one year.

6. Examinations in part of the subjects required for entrance may be taken one year before entering college.

7. For information concerning expenses, scholarships, etc., see "General Information."

8. For information concerning admission to short courses see "Short Courses."

G. Unclassified Students.

All requests for information concerning admission of unclassified students should be addressed to Professor W. P. B. Lockwood, chairman of committee on unclassified students.

Students not candidates for a degree (unclassified students) are admitted under the following provisions: —

1. No entrance examination is required, but applicants must bring certificates showing that they have finished a four-years high school course or its equivalent, and furnish satisfactory testimonials as to moral character.

2. No applicant under twenty-one years of age will be admitted as an unclassified student.

3. Each unclassified student must take from the regular courses a minimum of twelve credit hours a week.

4. In order to be admitted to any course, an unclassified student must have had all prerequisite subjects for that course.

5. Every unclassified student must do all the work of the courses elected, and take all examinations therein. In order to pass such courses he must attain a grade of at least 75 per cent. An unclassified student who passes in less than two-thirds of his work will be dropped from college.

6. All unclassified students are subject to the supervision of a special committee.

7. Any unclassified student may be dropped from college at any time if his presence in any class is undesirable or his work is unsatisfactory; and no unclassified student will be allowed to remain in college more than four semesters without the special permission of the faculty.

8. Unclassified students are subject to the regulations applying to classified students.

9. No student of this or any other institution who has not done efficient work therein shall be permitted to register as an unclassified student.

10. No unclassified student shall be allowed to participate in any intercollegiate contests.

Courses of Instruction.

A. TABLE OF FRESHMAN AND SOPHOMORE SUBJECTS.[1]

The figures indicate the number of credit hours a week. For details, see the descriptions of courses.

Freshman Year.

First Semester.

All work required.

Subjects.	Hours per Week.
Chemistry,	3
Algebra,	3
Solid Geometry,[2]	2
English,	4
Public Speaking (at option of instructor),	1
French or German,[3]	4
Drill,	1
Hygiene,	1
College Life (attendance without credit).	
	18 or 19

Second Semester.

All work required.

Subjects.	Hours per Week.
Animal Husbandry,	2
Chemistry,	3
Trigonometry,	3
Algebra,	2
English,	4
Public Speaking (if not taken in semester one),	1
French or German,	4
Drill,	1
Physical Education,	1
	20 or 21

[1] Applies to the classes of 1917 and 1918 only. See next page for course of study for class of 1919.

[2] To be taken in course when not offered for entrance.

[3] Students who have had three or four years of one language in the preparatory school will elect the other language. Students who have had two years of one language may have their choice of election. Whichever language they so elect must be continued to the end of the first semester of the sophomore year. Eleven college credits are required in this language.

Sophomore Year.

First Semester.

All work required except Chemistry or Animal Husbandry.

Subjects.	Hours per Week.
Agronomy,	3
Physics,	5
Zoölogy,	3
English,	2
French or German,	3
Tactics,	1
Drill,	1
	18
[Chemistry or Animal Husbandry (may be elected subject to approval by the dean),	3]
	[21]

Second Semester.[1]

Required.

Subjects.	Hours per Week.
Elementary Horticulture,	2
Botany,	4
English,	2
Agricultural Industry,	3
Drill,	1
Tactics,	1
Physical Education,	1
	14

Elective.

French or German, Geology, Physics, Chemistry, Surveying,	Each 3 hours. Any two,	6
		20

The following table shows the course of study that will be in effect with the entrance of the class of 1919: —

Freshman Year.

First Semester.

English and Public Speaking,	4 or 3
Algebra,	3
Geometry,	2
Chemistry,	3
Drill, etc., 2; Military Tactics, 1,	3
Language,	3
Agriculture and Horticulture,	2
	20 or 19

Second Semester.

English and Public Speaking,	4 or 3
Trigonometry,	3
Algebra,	2
Chemistry,	3
Drill, etc., 2; Military Tactics, 1,	3
Agricultural Geology,	3
Language,	3
Agriculture and Horticulture,	2
	23 or 22

[1] All courses under "Required," with any two of those under "Elective."

SOPHOMORE YEAR.

First Semester.

Physics,	4
English,	2
Zoölogy,	3
Rural Community,	2
Drill, etc.,	2
2 or 3 electives,	6 or 9
	19 to 22

Second Semester.

Agronomy,	3
English,	2
Botany,	4
Drill, etc.,	2
Agricultural Industry,	3
2 or 3 electives,	6 or 9
	20 to 23

Electives (subject to Revision).

Language,	3
Mathematics,	3
Agriculture,	3
Chemistry,	3
Free-hand Drawing,	3
Anthropology,	3

Electives (subject to Revision).

Language,	3
Agriculture (?),	3
Chemistry,	3
Entomology,	4
Geology,	3
Surveying,	3
Horticulture,	3
Physics,	4
Zoölogy,	3
Agricultural Education (?),	3
Mechanical Drawing,	3

B. MAJORS: JUNIOR AND SENIOR YEARS.

General Statement.

A major consists of 30 hours of correlated work, to be arranged by the student and an instructor called the adviser.

The list of courses found under each major on subsequent pages should not be considered as necessarily a rigid program to be followed. The heads of departments have suggested this series of courses as the best for the average man majoring in their departments. Advisers may, however, make modifications to suit the particular needs of the student, provided these modifications conform precisely to the class schedule as published for the year.

Rules governing Majors.

Rule 1. *Election.* — Each student, in the second semester of his sophomore year, shall elect a major subject from the list of majors given below; and this major shall consist of 30 credit hours of correlated work.

Rule 2. *Minimum Credits.* —The minimum number of credits for the junior and senior years shall be 65, inclusive of Military Drill and Physical Education.

Rule 3. *Maximum Credits.* — The maximum number of credits for any semester of the junior or senior year shall be 21.

Rule 4. *Humanities and Rural Social Science.* — A minimum of 12 credit hours in the Divisions of the Humanities and Rural Social Science will be required of all students during their junior and senior years, with the following restriction: that a minimum of 3 credit hours will be required in each of the divisions.

Rule 5. *Advisers.* — The work of each junior and senior will be under the immediate supervision of an instructor designated as major adviser. Ordinarily, the major adviser will be the head of the department in which the student intends to elect his major. Each student should consult with the adviser as soon as possible. The adviser has full authority to prescribe the student's work up to 30 hours. It is understood, however, that so far as practicable the individual needs of the student will be recognized. It is also hoped and expected that students will be disposed to seek the counsel of the adviser with respect to the remaining courses required for graduation.

Rule 6. *Free Electives.* — Each student is required to take 30 hours in his major and also 12 hours in the Divisions of the Humanities and Rural Social Science, making a total of 42 hours. He is allowed free choice of courses to complete his required hours, this remainder amounting to 17 hours minimum, or 37 hours maximum for the two years.

Rule 7. *Registration.* — No upper classman shall register until his major course of study is approved by his adviser.

(1) Course cards for recording the election of majors will be issued from the registrar's office on June 1.

(2) This card must be submitted by each student to his major adviser, who will lay out the course for the year and countersign the card.

(3) Each course card must be filled out, giving the name of student, his college address, the name of parent or guardian, and the student's home address. When the major courses have been entered on this card, and the hours of free elections added by the student, the card must be returned to the registrar not later than June 10.

Rule 8. *Changes.* — Applications for changes may be made to the dean in writing at any time; when approved by him and by the committee on scholarship, they become operative at the beginning of the semester following, provided that no change in the selection of a major may be made by any student after registration day of his senior year.

LIST OF MAJORS.

Agriculture.

Professor James A. Foord, Adviser.

Course.	Credit.
Agronomy 3,	3
Agronomy 6,	3
Animal Husbandry 3,	3
Animal Husbandry 5,	3
Animal Husbandry 9,	3
Dairying 1,	3
Dairying 2,	3
Farm Administration 3,	3
Farm Administration 4,	3
Microbiology 1 and 2,	5
	32

Chemistry 7 and 8, Veterinary Science 1, Microbiology 2, Pomology 1 and Animal Husbandry 6 are suggested as additional courses for the student fitting himself for general agriculture.

Agronomy.

Associate Professor Sidney B. Haskell, Adviser.

Course.	Credit.
Agronomy 3,	3
Agronomy 4,	3
Agronomy 5,	3
Agronomy 6,	3
Agronomy 8,	3
Animal Husbandry 9,	3
Farm Administration 4,	3
Chemistry 5,	5
Chemistry 6,	5
	31

Animal Husbandry.

Associate Professor J. Allan McLean, Adviser.

Course.	Credit.
Agronomy 3,	3
Veterinary Science 1, Veterinary Hygiene and Stable Sanitation,	3
Veterinary Science 2, General Veterinary Pathology (Materia Medica and Therapeutics),	3
Animal Husbandry 5,	3
Animal Husbandry 6,	1
Animal Husbandry 8,	2
Animal Husbandry 9,	3
Animal Husbandry 10,	3
Animal Husbandry 11,	2
Dairying 1,	3
Farm Administration 3,	3
Farm Administration 4,	3
	32

Dairying.

Professor William P. B. Lockwood, Adviser.

Course.	Credit.
Animal Husbandry 5,	3
Animal Husbandry 6,	1
Animal Husbandry 8,	2
Animal Husbandry 9,	3
Animal Husbandry 11,	2
Dairying 1,	3
Dairying 2,	3
Dairying 3,	3
Microbiology 11 and 12,	3
Farm Administration 3,	3
Farm Administration 4,	3
	29

Poultry Husbandry.

Professor John C. Graham, Adviser.

Course.	Credit.
Poultry Husbandry 1,	2
Poultry Husbandry 2,	2
Poultry Husbandry 3,	1
Poultry Husbandry 4,	1–3
Poultry Husbandry 5,	1
Poultry Husbandry 6,	3
Poultry Husbandry 7,	3
Poultry Husbandry 9,	3
Pomology 1,	3
Agronomy 3,	3
Animal Husbandry 5,	3
Animal Husbandry 9,	3
Veterinary Science 7,	3
	31–33

Floriculture.

Associate Professor Arno H. Nehrling, Adviser.

Course.	Credit.
Floriculture 1,	4
Floriculture 2,	4
Floriculture 3,	3
Floriculture 4,	3
Horticulture 3,	3
Horticulture 4,	3
Entomology 1,	3
Market Gardening 2,	3
Botany 2,	4
	30

Note. — Horticulture 3 and 4 is a junior subject, but to balance the work for the two years it would be better for the floricultural students to take the course in the senior year.

Forestry.

Professor William D. Clark, Adviser.

Course.	Credit.
Forestry 3,	3
Forestry 4,	3
Forestry 5,	5
Forestry 6,	3
Entomology 5,	3
Landscape Gardening 1,	3
Horticulture 3,	3
Horticulture 4,	3
Botany 13,	4
	30

Students who propose to major in Forestry should elect Geology and Surveying in sophomore year.

Landscape Gardening.

Professor Frank A. Waugh, Adviser.

Course.	Credit.
Landscape Gardening 1,	3
Landscape Gardening 2,	3
Landscape Gardening 3,	3
Landscape Gardening 4,	3
Landscape Gardening 5,	2
Landscape Gardening 6 or 10,	2
Landscape Gardening 7,	3
Landscape Gardening 8,	3
Drawing 1,	3
Drawing 2,	3
Horticulture 3,	3
	31

Courses for juniors *only:* Landscape Gardening 1 and 2, Drawing 1 and 2.

Courses for seniors and graduates *only:* Landscape Gardening 3, 4, 7 and 8.

Courses open to juniors and seniors, both if possible: Horticulture 3 and 4.

This grouping of subjects is offered only as an example. Other groupings may be approved by the adviser, but such other groupings must be subject to the class schedule.

Pomology.

Professor Fred C. Sears, Adviser.

Course.	Credit.
Pomology 1,	3
Pomology 2,	3
Pomology 3,	3
Pomology 4,	3
Pomology 5,	3
Pomology 6,	2
Botany 5,	2
Agronomy 5,	3
Entomology 1,	3
Entomology 2,	3
	28

Agricultural Chemistry.

Associate Professor Charles A. Peters, Adviser.

Course.	Credit.
Chemistry 5,	5
Chemistry 6,	5
Chemistry 9,	5
Chemistry 10,	5
Chemistry 11,	5
Chemistry 12, 14 or 16,	5
Chemistry 13,	3
Chemistry 15,	3
Chemistry 18,	2
	38

The major will consist of 30 credit hours selected from this list. The student will be advised concerning other subjects suitable to be taken in connection with Chemistry.

Economic Entomology.

Professor Henry T. Fernald, Adviser.

Course.	Credit.
Entomology 1,	3
Entomology 2,	2
Entomology 3,	4
Entomology 4,	4
Entomology 5,	3
Entomology 8,	3
Botany 3,	4
Botany 4,	3
Zoölogy 3,	3
Zoölogy 4,	3
	32

A major in Economic Entomology does not necessarily include all the subjects given in this list, but may be varied to some extent, in accordance with the future plans of the student, other modifications being permissible.

Microbiology.

Professor Chas. E. Marshall, Adviser.

Course.	Credit.
Microbiology 1 or 2,	5
Microbiology 3 or 4,	5
Microbiology 5 or 6,	3
Microbiology 7 or 8,	3
Chemistry 3,	5
Chemistry 4,	5
Chemistry 5,	3
Chemistry 6,	3
	32

Courses 9 in Chemistry; 3, 4, 5 in Botany; 3, 4, 5, 6 in Zoölogy; 1, 3, 5, 6 in Veterinary Science, together with German and French, are suggested as collateral lines. Dairying 1 and Agronomy 5 are essential to a grasp of the larger problems involved in Microbiology as applied to Agriculture.

Plant Physiology and Pathology.

Professor GEORGE E. STONE,[1] Adviser.

Course.	Credit.
Botany 3,	4
Botany 4,	3
Botany 9,	4 or 5
Botany 10,	4 or 5
Botany 11,	4
Botany 12,	4
Chemistry 5,	5
Chemistry 6,	5
	33 or 35

Agricultural Education.

Professor WILLIAM R. HART, Adviser.

Course.	Credit.
Agricultural Education 1,	3
Agricultural Education 2,	3
Agricultural Education 3,	3
Agricultural Education 4,	3
Agronomy 3,	3
Dairying 5,	2
Farm Administration 3,	3
Poultry Husbandry 1,	2
Market Gardening 2, Agronomy 5,	3
Botany 5,	2
Pomology 1,	3
	30

Some substitutions of other technical courses for some of the technical courses above mentioned will be made to meet the needs of individual students.

Rural Social Science.

Associate Professor ALEXANDER E. CANCE, Adviser.

Course.	Credit.
Economics and Sociology 1,	3
Agricultural Economics 3,	3
Agricultural Economics 7,	3
Agricultural Economics 6 or 8,	3
Rural Sociology 1,	3
Rural Sociology 4,	1
Rural Sociology 5,	3
Rural Sociology 8 or 10,	3
Rural Sociology 11,	3
Farm Administration 4,	3
	28

[1] On leave of absence; Associate Professor Osmun acting as head of Department of Botany.

Summary.

There are four preliminary steps which a student should take in arranging for his major work.

1. Select a major.
2. Confer with major adviser for arrangement of courses, the plan to be approved by adviser in accordance with Rule 5 previously stated.
3. Select courses covering the four semesters of the junior and senior years in such a way that a minimum of 12 credits will be taken in the two divisions, the Humanities and Rural Social Science; the distribution of all but 3 of these credits may be decided by the student.
4. Choose other courses so that the total number of credits for any semester shall be not less than 16 nor more than 21. (See Rules 2 and 3.)

C. UNDERGRADUATE COURSES.

All courses given in the *first semester bear odd numbers*; all given in the *second semester bear even numbers*. Studies are pursued in courses, "course" implying the study given a subject within one semester, without regard to the total number of hours or to the number of credits. The special mention of certain courses as prerequisite to other courses does not imply that no courses but those so mentioned are "preliminary or preparatory" within the meaning of the Book of Rules.

DIVISION OF AGRICULTURE.

Professor Foord.

AGRONOMY.

Associate Professor Haskell, Dr. Brooks, Assistant Professor McDonald, Mr. Merkle.

Required Course.

1. Soils and Fertilizers. — A study of the formation, classification and physical and chemical properties of soils. This is followed by study of methods of soil improvement and of maintenance of fertility, including the use of farm manures, commercial fertilizers and soil amendments. Prerequisites, Chemistry 1 and 2. Sophomores; 3 hours. Credit, 3.
Associate Professor Haskell and Assistant Professor McDonald.

Elective Courses.

3. Field and Forage Crops. — History, classification, production, harvesting, commercial grading and valuation. The crops studied are the cereal grains, grasses, legumes, forage and root crops suitable to New England conditions. The work includes lecture, laboratory and field study of these various crops. Prerequisites, Agronomy 1 and Botany 2. For juniors primarily; 1 lecture and 2 laboratory periods. Credit, 3.
Assistant Professor McDonald.

4. Advanced Field Crops. — Commercial production of grain, hay and root crops. Lecture, laboratory, and field study of the purity, quality, and vitality of the seed of these crops and the handling, grading and judging of their products. The work offered will not be confined to New England conditions. Prerequisite, Agronomy 3. For juniors primarily; 2 lectures and 1 laboratory period. Credit, 3. Assistant Professor McDonald.

5. Advanced Soils. — A field, laboratory and lecture course on soils, their nature, composition, physical qualities, improvement. Field work, as far as the season allows, consists of detailed soil surveys in different parts of the Connecticut valley; this followed by laboratory work on the physical properties of the soil collected, on the effect of fertilizers on the soil, and on the mixing of fertilizers. Prerequisite, Agronomy 1. For seniors primarily; 1 lecture period and 1 4-hour laboratory period weekly. Credit, 3.
Associate Professor Haskell.

6. Drainage and Irrigation. — A field and lecture course on soil improvement, by drainage and irrigation. As a thesis each man is required, after studying an area of wet or swampy land, to present plans and estimates for its reclamation. Prerequisites, Agronomy 1 and Mathematics 6. Juniors and seniors; 1 lecture period and 1 4-hour laboratory period weekly. Credit, 3.

Associate Professor Haskell.

8. Manures and Fertilizers. — An advanced course, giving a general discussion of the different theories which have been held relative to the functions and importance of manures and fertilizers, and leading up to the views at present accepted. Each of the important manures and fertilizers will be discussed, its origin and its chemical and physical characteristics being considered. Each material taken up will be studied in relation to its capacity to supply plant food and to its effects upon soil texture, moisture, temperature and flora. Considerable attention will be devoted to consideration of the experimental work which has been done, and which is now in progress, on manures and fertilizers. This course is intended for seniors only. Prerequisite, Agronomy 1; 3 lectures a week, with occasional seminars. Credit, 3.

Associate Professor Haskell.

10. Breeding of Field Crops. — This course deals with the improvement, by selection and breeding, of the crops studied in courses 3 and 4. Prerequisite, Agronomy 4. Seniors only; 2 lecture periods weekly. Credit, 2.

Associate Professor Haskell.

ANIMAL HUSBANDRY.

Associate Professor McLean, Assistant Professor Quaife.

Required Course.

2. Market Classes and Grades of Live Stock. — A study of the different market classes and grades of horses, cattle, sheep and swine. The purpose of this course is to familiarize beginners with the different classes of stock, and to give them a grounding in live stock judging. Text-book, Craig's "Live Stock Judging." Freshmen; 2 laboratory periods. Credit, 2.

Associate Professor McLean and Assistant Professor Quaife.

Elective Courses.

3. Breeds and Types of Live Stock. — A course covering the origin, history, development and characteristics of the different breeds of horses, cattle, sheep and swine. Text-book, Plumb's "Breeds and Types of Farm Animals." Prerequisite, Animal Husbandry 2. Sophomores; 2 lectures and 2 laboratory periods. Credit, 4.

Associate Professor McLean and Assistant Professor Quaife.

5. Principles of Breeding. — This course is designed to familiarize the student with the problems involved in animal and plant improvement; to acquaint him with the facts which are already established; to scrutinize prevailing theories; and to indicate the lines and methods of further work. Some of the subjects studied are: variations, their causes and heritability; De Vrie's

theory of mutations; the inheritance of acquired characters; the pure line; Mendelian law; the making of new types; the determination of sex; applications to human heredity. A few periods at the end of the course are devoted especially to the application of principles in live stock improvement. Text, "Genetics," by Herbert E. Walter. Supplementary reading. Prerequisite, Zoölogy 1; 3 lectures. Credit, 3. Associate Professor McLean.

6. Live-stock Management. — The work of this course consists of laboratory work by the individual students in the handling of live stock; with horses, such work as halter breaking, breaking to drive, driving, harnessing, casting and fitting for show will be done; similarly, the practical handling of cattle, sheep and swine will be fully treated. Special study is given to halter making, splicing, hitches, knots and all rope work. Prerequisite, Animal Husbandry 3. Juniors; 1 laboratory period. Credit, 1.
Assistant Professor Quaife.

8. Advanced Stock Judging. — This course is designed to equip Animal Husbandry students in the judging of classes of different types of live stock; to strengthen them in the selection of superior sires; and equip them for stock judging at fairs. Visits will be made to the best herds for the various breeds of stock in the State. Judging teams to represent the college will be selected largely from this class. Must be preceded by or accompany Animal Husbandry 6. Juniors; 2 laboratory periods. Credit, 2.
Associate Professor McLean.

9. Feeding and Management. — A study of the principles of animal nutrition; of the composition and qualities of feeding materials; of the feeding, care and management of dairy cattle from birth to maturity, with especial attention to economic production. Text-book, Henry's "Feeds and Feeding." Prerequisite, Chemistry 5 or 7. Seniors; 3 lectures. Credit, 3.
Assistant Professor Quaife.

10. Feeding and Management. — A continuation of Course 9, dealing in a similar manner with horses, sheep, beef cattle and swine. Prerequisite, Course 9. Seniors; 3 lectures. Credit, 3. Assistant Professor Quaife.

11. Herd and Stud-book Study. — An advanced course in the study of the breeds of live stock, familiarizing the student with the detailed history of the breed, the most productive sires and dams of the various breeds, and the successful lines and methods of breeding. Prerequisites, Animal Husbandry 5 and 8. Seniors; 2 hours. Credit, 3. Associate Professor McLean.

12. Seminar. — Advanced study upon questions pertaining to live stock and live-stock production. Each student electing this work will choose some particular line of work in which he is specially interested, and will pursue study in this subject by reading, compilation and research. There will be no regular lecture period, but seminars will be held. A satisfactory report of the results must be presented in a thesis. Open only to seniors majoring in Animal Husbandry. Credit, 1. Associate Professor McLean.

DAIRYING.

Professor Lockwood, Mr. Coons, Mr. Baldinger.

Elective Courses.

1. Milk and Milk Composition. — The development of the dairy business in the United States; the composition, secretion and general characteristics of milk; contamination and fermentation; the study of analysis of milk products by use of the Babcock test for fat, test for acidity and adulteration, and ordinary preservatives; moisture tests for butter; methods for testing herds and developing them to higher efficiency; problems. Two lecture hours and 1 2-hour laboratory period. Credit, 3.
Professor Lockwood and Mr. Coons.

2. Buttermaking. — A study of separators and cream separation; handling milk and cream for buttermaking; preparation of starters, and ripening cream; churning; markets and their requirements; marketing, scoring and judging butter; management; problems; dairy machinery and care thereof. Prerequisite, Course 1; 1 lecture hour and 2 2-hour laboratory periods. Credit, 3. Professor Lockwood, Mr. Coons and Mr. Baldinger.

3. Market Milk and Milk Products. — A study of market milk conditions, extent and development of the business; supply and delivery; food value of milk and its use as food; milk and its relation to the public health; methods for the proper handling and preparing of milk and cream for direct consumption; certified milk, requirements and production; pasteurizing; sterilizing; standardizing and modifying; milk laws and inspection. The manufacture of milk products other than butter, including cheese, condensed milk, cottage cheese, casein, milk powder, ice cream, etc. Prerequisites, Dairying 1, and Bacteriology 1; 2 lecture hours and 1 2-hour laboratory period. Credit, 3. Professor Lockwood and Mr. Baldinger.

4. Dairying. — A course designed primarily for teachers of secondary agriculture. The work given will cover briefly the composition and secretion of milk, the Babcock fat test, the relation of bacteria to dairy work and principles of creaming; separators; elementary buttermaking; proper methods of handling milk and cream; and the relation of market milk to the public health. One lecture hour and 2 2-hour laboratory periods. Credit, 3.
Professor Lockwood.

FARM ADMINISTRATION.

Professor Foord.

Elective Courses.

3. Farm Buildings and Machinery. — A study of the material equipment of the farm aside from the land; farm buildings, their location, plan and arrangement; water supply; fencing problems; farm power; farm machinery; wagons. Prerequisites, Agronomy 1, Animal Husbandry 2, Physics 1. Primarily for seniors; 2 laboratory periods and 1 lecture hour. Credit, 3.
Professor Foord.

4. Farm Management. — The organization of the farm as a business enterprise. A discussion and study of some of the problems that confront the modern farmer, such as the choice of a farm, systems and types of farming, labor, marketing, records and farm accounts. Prerequisites, Agronomy 1 and 3, Animal Husbandry 2 or 3. Primarily for seniors; 2 lecture or recitation hours and 1 laboratory period. Credit, 3. Professor Foord.

POULTRY HUSBANDRY.

Professor Graham, Dr. Goodale, Mr. Payne.

Elective Courses.

1. Elements of Poultry Culture. — This course consists of a comprehensive study of poultry-house construction, poultry-house equipment, winter-egg production, types and breeds of poultry. Juniors; 2 lectures. Credit, 2. Professor Graham.

2. Elements of Poultry Culture. — This is a continuation of Course 1, treating the subjects of incubation, brooding, care of growing stock, market poultry, including capons, roasters and broilers, and diseases of poultry. Juniors; 2 lectures. Credit, 2. Professor Graham.

3. Poultry Practice Work. — This is a practical laboratory course in poultry carpentry, caponizing, killing and picking; dressing and packing poultry, sorting and preparing eggs for market. Must be preceded or accompanied by Course 1. Juniors; 1 laboratory period. Credit, 1. Mr. Payne.

4. Incubation and Brooding. — In this course students are required to set up and operate incubators and brooders, make a systematic study of the development of the chick in the egg, and the care of sitting hens. This course must be preceded or accompanied by Course 2. Juniors; time to be arranged. Credit, 1 to 3. Mr. Payne.

6. Poultry Management. — In this course a detailed study of large poultry farms and equipment, such as bone cutters, feed cutters, cramming machines, etc., will be carried on. It includes the laying out and planning of poultry buildings of all kinds, the mating of fowls, and the preparing of birds for exhibition. Attention to poultry diseases and investigation work carried on by experiment stations is prominent in this course. A few good poultry plants will be visited by the class for practical demonstrations. Prerequisites, Courses 1, 2, 3 and 4. Seniors; 2 lectures, 1 laboratory period. Credit, 3. Professor Graham and Mr. Payne.

7. Advanced Poultry Judging. — This course includes a study of the origin and history of breeds and varieties, poultry organizations and poultry shows. The American Standard of Perfection will be used as a text. Prerequisites, Courses 1, 2, 3, 4 and 5. Seniors; 1 lecture and 2 laboratory periods. Credit, 3. Mr. Payne.

8. Investigational Work. — This course is designed especially for students who are planning to do experiment station work. Students will be assigned specific problems to work out experimentally, or they may be required to assist in carrying on such work. Credit, 1 to 3. Dr. Goodale.

9. Market Poultry and Poultry Products. — This course includes the study of market classifications of poultry, eggs and feathers; the requirements of different markets, methods of marketing, advantages and disadvantages of cold storage of poultry and eggs. Students will be required to fatten several lots of chickens by different methods and rations. Accurate data must be kept showing the gain in weight and quality, also the cost of feed, labor, etc., and the profit and loss. Judging and scoring of market poultry, both alive and dressed, and market eggs will be an important feature of this course. Prerequisites, Courses 1, 2 and 3. Seniors; 1 lecture or conference period and laboratory periods to be arranged. Credit, 3. Mr. Payne.

10. Pen Management. — This is a practical laboratory course. Students are required to care for a pen of fowls, keeping accurate records of eggs produced, food consumed, weather conditions, health of fowls, and profit and loss; must be preceded or accompanied by Course 1. Juniors; time to be arranged. Credit, 1. Mr. Payne.

RURAL ENGINEERING.

Associate Professor Gunness.

Elective Courses.

3. Farm Structures. — A study of the strength, durability and cost of building materials; location and planning of farm buildings; water supply; lighting and heating systems for the farm; drawing plans, writing specifications and estimating cost of buildings. Concrete construction as applied to foundations, silos, tanks, posts, floors and walks. One lecture and 2 laboratory periods. Credit, 3. Associate Professor Gunness.

4. Farm Machinery. — A study of the care and operation of tillage, seeding, harvesting, pumping and spraying machinery; steam and gas engines. Special attention will be given to the use of power on the small farm. Practice in the adjustment of the various machines, babbitting and fitting bearings, lining shafts and pulleys, lacing belts, splicing rope and packing valves. One lecture, and 2 laboratory periods. Credit, 3.

Associate Professor Gunness.

DIVISION OF HORTICULTURE.

Professor WAUGH.

[The general subject of horticulture divides naturally into subjects of pomology, floriculture, forestry, landscape gardening and market gardening. A number of courses relate to more than one of these subjects, and are therefore grouped here under the general designation of horticulture.]

2. NURSERY PRACTICE. — This course treats of the fundamental methods of plant propagations by seeds, cuttings, budding, grafting, etc. Lectures and practicums. Sophomores, 1 lecture period and 1 laboratory period. Credit, 2. Assistant Professor CHENOWETH.

Elective Courses (General).

3. PLANT MATERIALS. — This course aims to make the student familiar with the character of the trees, shrubs and herbaceous perennials used in ornamental work, and with the methods of propagating them. Prerequisite, Horticulture 2; 2 lecture periods and 1 laboratory period. Credit, 3.

4. PLANT MATERIALS. — A continuation of Course 3, taking up the field use of trees, shrubs and herbaceous plants, their native habitats, soils and plant associations, with a view to supplying to students in landscape gardening and floriculture a knowledge of plant species. Frequent practicums and field excursions. Prerequisite, Horticulture 3; 2 lecture periods and 1 laboratory period. Credit, 3.

6. PLANT BREEDING. — This course is designed to introduce advanced students to the best modern views of variation, heredity and evolution, and to the best methods of studying the phenomena found in these subjects. The principles educed apply to both animal breeding and plant breeding, but the laboratory work (of which there is considerable) is concerned chiefly with plant life. Some practice work in hybridization and selection is undertaken, and students are trained as far as possible in the practical application of those principles which have direct bearing on the breeding of plants and the cultivation of crops. Seniors and graduates; open only to students well prepared in agricultural or horticultural subjects; 2 lecture periods and 1 2-hour laboratory period. [Not given in 1914–15.] Credit, 3.

FLORICULTURE.

Associate Professor NEHRLING, Mr. THURSTON.

Elective Courses.

1. GREENHOUSE MANAGEMENT. — This course is designed to familiarize students with the methods followed in the management of greenhouse crops. The students are instructed in the practical operation of glazing, concrete bench construction, watering, potting, fumigation, ventilating, and in the

methods of propagation of plants by seeds and cuttings. They will also be expected to arrange their hours according to the needs of the work. Prerequisite, Horticulture 2. Juniors; lectures 2, laboratory 6 hours. Credit, 5.
Associate Professor NEHRLING, Mr. THURSTON.

2. GREENHOUSE MANAGEMENT. — Continuation of Course 1. In addition, work in the use of cut flowers and plants in decorative work, the arrangement of flowers in baskets, designs, vases, table and home decorations will be considered. The design, construction, cost, maintenance, heating, ventilating of greenhouse structures, and the draughting of specifications for commercial houses and private ranges will also be studied. Juniors; lectures 2, laboratory 6 hours. Credit, 5. Associate Professor NEHRLING, Mr. THURSTON.

3. COMMERCIAL FLORICULTURE. — A detailed study will be made of the methods of culture of greenhouse plants and cut flowers for wholesale and retail markets. The care and marketing of all florists' crops will also be considered. Assigned readings on these topics. Prerequisite, Floriculture 1 and 2. Seniors; lectures 2, laboratory 3 hours. Credit, 4.
Associate Professor NEHRLING.

4. COMMERCIAL FLORICULTURE. — A continuation of Course 3. In addition, a study of the types of tropical and subtropical foliage and flowering plants used in conservatory work will be made. Prerequisite, Floriculture 1, 2 and 3. Seniors; lectures 2, laboratory 3 hours. Credit, 4.
Associate Professor NEHRLING.

FORESTRY.

Professor CLARK.

Elective Courses.

1. PRINCIPLES OF FORESTRY. — A lecture course for the purpose of giving the students a general view of the whole field of forestry and what forestry attempts to accomplish and has accomplished. Two lectures; juniors and seniors; not required of students who propose to major in forestry. Credit, 2.
Professor CLARK.

2. WOOD TECHNOLOGY. — A study of the commercial woods found in the lumber markets, methods of identification, uses, strength values, technical qualities, decay and methods of preservation. Juniors; 1 lecture and 2 laboratory periods. Credit, 3. Professor CLARK.

3. DENDROLOGY. — During the first part of the semester frequent field trips will be made to identify and study the habits of our native forest trees. Later, the classification, range, distribution, forest habits, quality, uses and identification of wood of the commercial timber trees of the United States will be studied. Two 2-hour periods; lectures, recitations, laboratory or field work at option of instructor; juniors. Credit, 3. Professor CLARK.

4. Silviculture. — Factors influencing forest growth; forest types; silvicultural systems; care and protection of forests; forest description; forest nursery practice and forest planting. Three lectures weekly until May 1; during May and June, 1 lecture and 1 4-hour field period weekly; juniors. Prerequisite, Forestry 3. Credit, 3. Professor Clark.

5. Forest Mensuration. — Methods of determining the volume of trees, logs and entire forests. Methods of computing volume tables, tree and forest growth and yield tables. Timber estimating. Three lectures; 72 hours of field work; seniors. Credit, 5. Professor Clark.

6. Seminar — Report. — This may involve research, laboratory or field work in the investigation of some subject, together with a review of the literature relating to it and an original written report evidencing the results. Subject to be chosen in conference with Professor Clark. Seniors. Credit, 3.
Professor Clark.

LANDSCAPE GARDENING.

Professor Waugh, Assistant Professor Harrison.

Elective Courses.

1. Elements of Landscape Gardening. — Reconnoissance surveys and mapping, with special reference to the methods used in landscape gardening; detailed study of selected designs of leading landscape gardeners; grade design, road design and field work. Students should have preparation in surveying, mathematics, plant materials and drawing. Must be followed by Course 2. Juniors; 6 hours a week. Credit, 3.
Assistant Professor Harrison.

2. Elements of Landscape Gardening. — As stated under Course I. Prerequisite, Course 1.

3. General Design. — Field notes; examination of completed works and those under construction; design of architectural details, planting plans, gardens, parks and private grounds; written reports of individual problems. Seniors; prerequisites, Landscape Gardening 1 and 2, and either plant materials (Horticulture 3 and 4) or advanced mathematics; must be followed by Course 4; 6 hours. Credit, 3. Assistant Professor Harrison.

4. General Design. — As stated under Course 3. Prerequisite, Course 3.

5. Theory of Landscape Art. — The general theory and applications of landscape study, including a brief history of the art. Seniors and graduates; 2 hours. Credit, 2. Professor Waugh.

6. Architecture. — The history of architectural development, the different historic types, with special reference to the underlying principles of construction and design and their relations to landscape design. Illustrated lectures, conferences, practice in designing; 2 hours. (Alternating with Course 10 and not to be given in 1913–14.) Credit, 2.
Assistant Professor Harrison.

7. Civic Art. — The principles and applications of modern civic art, including city design, city improvement, village improvement and rural improvement. Prerequisites, Courses 1, 2 and 3; must be followed by Course 8; 6 hours. Credit, 3. Professor Waugh.

8. Civic Art. — As stated under Course 7. Prerequisite, Course 7.

10. Construction and Maintenance. — Detailed instruction in methods of construction and planting in carrying out plans, in organization, reporting, accounting, estimating, etc.; maintenance work in parks and on estates, its organization, management, cost, etc. (Alternating with Course 6.) Two hours. Credit, 2. Assistant Professor Harrison.

MARKET GARDENING.

————[1]

Elective Courses.

2. Elements of Market Gardening. — A course designed for an introduction to market gardening as a business. The work consists primarily of actual field experience in handling vegetable crops from seed to maturity. This is supplemented with lectures and text-book, in which a study of methods, soils, fertilization, tillage and management is made. Juniors; 5 hours. Credit, 3. ————

3. Advanced Market Gardening. — A continuation of the work begun in Market Gardening 2, taking up problems of seed growing, selection of varieties, crop management, harvesting, storage and marketing. A study is made of the greenhouse vegetable industry, and considerable time devoted to growing the special forced crops. Some time is given to a systematic study of vegetable description, classification and nomenclature. Collateral reading is required. Seniors; prerequisite, Market Gardening 2; 5 hours. Credit, 3. ————

POMOLOGY.

Professor Sears, Assistant Professor Chenoweth.

Elective Courses.

1. Practical Pomology. — *General.* — A study of the general principles of the growing of fruits, dealing with such questions as selection of site, soils, windbreaks, laying out plantations, choice of nursery stock, pruning, etc. Text and reference books; field and laboratory exercises. Prerequisite, Horticulture 2. Juniors; 4 hours. Credit, 3. Professor Sears.

2. Practical Pomology. — *Special.* — The special application of the general principles discussed in Course 1 to the culture of the principal kinds of fruits, such as apples, pears, peaches, plums, cherries and quinces; grape culture and the culture of small fruits, such as blackberries, raspberries, currants, gooseberries and strawberries. Text-books, lectures and reference books; field and laboratory exercises. Prerequisites, Horticulture 2 and Pomology 1. Juniors; 4 hours. Credit, 3. Professor Sears.

[1] Mr. Harold F. Tompson temporarily in charge.

3. Systematic Pomology. — A study of the varieties of the different fruits and of nomenclature, with critical descriptions; special reference being given to relationships and classification. Text-books, laboratory and field exercises. Prerequisites, Horticulture 2 and Pomology 1 and 2. Seniors; 4 hours. Credit, 3. Assistant Professor Chenoweth.

4. Systematic Pomology. — As stated under Course 3. Seniors; prerequisites, Horticulture 2, Pomology 1, 2 and 3; 4 hours. Credit, 3.
Assistant Professor Chenoweth.

5. Commercial Pomology. — The picking, storing and marketing of fruits, including a discussion of storage houses, the picking, handling and storing of fruits, fruit packages, methods of grading and packing, manufacturing, etc. Especial emphasis is placed upon laboratory and field work, where the student is given actual practice in the picking and packing of all the principal fruits, together with the manufacture of by-products. Open only to men majoring in Pomology. Prerequisites, Horticulture 2, Pomology 1 and 2. Seniors; 1 lecture and 2 laboratory periods. Credit, 3.
Assistant Professor Chenoweth.

6. Spraying. — A study of (*a*) spraying materials, their composition, manufacture and preparation for use; the desirable and objectionable qualities of each material, formulas used, cost, tests of purity. (*b*) Spraying machinery, including all the principal types of pumps, nozzles, hose and vehicles; their structure and care. (*c*) Orchard methods in the application of the various materials used, with the important considerations for spraying each fruit and for combating each orchard pest. This course is designed especially to familiarize the student with the practical details of actual spraying work in the orchard. Spray materials are prepared, spraying apparatus is examined and tested, old pumps are overhauled and repaired, and the actual spraying is done in the college orchards and small fruit plantations. Prerequisites, Horticulture 2, Pomology 1 and 2. Seniors; 3 hours (1 lecture period and 1 laboratory period). Credit, 2. Professor Sears.

DRAWING.

Mr. Oberhelman.

Elective Courses.

1. Free-hand Drawing. — Lettering; free-hand perspective; sketching from type models, leaves, flowers and trees, houses, etc.; laying flat and graded washes in water colors; water color rendering of leaves, flowers and trees; conventional coloring and map rendering in water colors; conventional signs and mapping in ink. Juniors; 6 hours. Credit, 3.
Mr. Oberhelman.

2. Mechanical Drawing. — Inking exercises; geometric problems; projection; intersections, isometric; shades and shadows; parallel; angular and oblique perspective; perspective drawing of buildings. Students should have preparation in plane and solid geometry. Juniors; 6 hours. Credit, 3.
Mr. Oberhelman.

DIVISION OF SCIENCE.

Professor Henry T. Fernald.

BOTANY.

Professor Stone,[1] Associate Professor Osmun, Mr. McLaughlin, Mr. Smith, ———————.

[The object of the courses in botany is to teach those topics pertaining to the science which have a bearing upon economic and scientific agriculture. Undergraduate work extending through five semesters is offered. Students sufficiently prepared are occasionally permitted to undertake special physiological and pathological investigations. A botanical conference is held monthly, wherein new problems in botanical science are considered by graduate students and the seniors who elect botany.]

Required Course.

2. General Botany. — The morphology, physiology and classification of plants. This course is fundamental. Its aim is to lay a foundation for the more specialized courses in botany which follow, and to provide a general knowledge of the science for those students who will not take further work in the department. This course is prerequisite to all other courses given by the department. In the laboratory much time is devoted to study of the structure of higher or seed plants. In this work first attention is given to the cell as the unit of structure; from the cell is traced the gradual development of the tissues of the entire plant. During the spring period of the semester much practice is given in determining and naming plants, Gray's "New Manual of Botany" being employed. In connection with this work each student is required to collect and prepare an herbarium of 75 species of plants. The lectures aim to amplify and interpret the laboratory work, dealing also with the function (physiology), classification (taxonomy) and ecology of plants. Though only 1 lecture period is scheduled for this course, it is understood that laboratory hours may be used for lectures at the discretion of the instructor. Sophomores; 1 lecture and 3 laboratory periods. Credit, 4.
Associate Professor Osmun, Mr. McLaughlin and Mr. Smith.

Elective Courses.

3. Cryptogamic Botany. — Systematic study of typical forms of the lower plants (bacteria, algæ, fungi, lichens, mosses and ferns); instruction in laboratory technique and methods; field excursions for the purpose of observing environmental habits and collecting material for laboratory study; collateral reading. This course is intended for those students who wish to specialize in any of the biological sciences, and is a prerequisite of Courses 9, 10, 15 and 16. Students electing this course may attend the lectures in Course 5. Prerequisite, Course 2. Primarily for juniors. One lecture hour and 3 2-hour laboratory periods. Credit, 4.
Associate Professor Osmun and Mr. McLaughlin.

4. Cryptogamic Botany. — As stated in Course 3. Prerequisite, Course 3. One lecture hour and 2 2-hour laboratory periods. Credit, 2.
Associate Professor Osmun and Assistant.

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[1] Absent on leave; Associate Professor Osmun acting as head of department.

5. Diseases of Crops. — This course comprises a study of the common diseases of crops, their nature, causes and methods of prevention and control. In the laboratory macroscopic examinations of diseases are made, and the principal experiment-station and government literature on plant diseases is read. Intended especially for students majoring in agronomy, floriculture, landscape gardening and pomology. Prerequisite, Course 2. Primarily for juniors; 1 1-hour lecture and 1 2-hour laboratory period. Credit, 2.
Professor Stone, Mr. McLaughlin and Mr. Smith.

7. Diseases of Crops. — This course is more specialized than Course 5, and is intended to meet the needs of the student who wishes to make a more thorough study of the diseases of the particular group or groups of crops in which his interest lies; *e.g.*, diseases of fruits, diseases of field crops, diseases of trees and shrubs. Laboratory work consists of microscopic and macroscopic examination of diseases, and extensive reading of literature concerning them. Prerequisite, Course 2. Students taking this course who have not previously taken Course 5 will attend the lectures in Course 5, and if they continue in botany the second semester, must take Course 8. Seniors; 1 lecture and 3 2-hour laboratory periods. Credit, 4. Associate Professor Osmun.

8. Diseases of Crops. — As stated in Course 7. Prerequisite, Course 7.

9. Plant Pathology. — This course embraces a comprehensive study of diseases of plants, including detailed training in laboratory methods and technique. Much time is devoted to the study of literature and representative life histories of pathogens, the making of pure cultures, and artificial inoculation of hosts. Students taking this course are fitted for civil service, experiment-station and college positions in plant pathology. Course 10 must follow. Prerequisites, Botany 2, 3 and 4. Seniors; 1 lecture and 4 2-hour laboratory periods. Credit, 5. Associate Professor Osmun.

10. Plant Pathology. — As stated in Course 9. Prerequisite, Course 9.

11. Plant Physiology. — This is a general course dealing with such topics as absorption, nutrition, growth, movement and the tropisms of plants, and requires previous training in organic chemistry and botany. Prerequisite, Botany 2. Seniors; 2 lectures and 3 2-hour laboratory periods. Credit, 4.
Professor Stone and Mr. McLaughlin.

12. Plant Physiology. — As stated in Course 11. Prerequisite, Course 11.

13. Shade-tree Management. — Physiology and pathology of shade-trees. This course includes a comprehensive study of the diseases, structure and functions of trees and shrubs, and of every agency which in any way affects shade-trees. Laboratory work and lectures; extensive reference reading. Designed for those students who intend to take charge of parks or large estates, or to become tree wardens, city foresters, landscape gardeners or professional advisers and caretakers. Prerequisite, Courses 2 and 5. Must be followed by Course 14. Seniors; 1 lecture period and 3 2-hour laboratory periods. Credit, 4. Professor Stone and Mr. Smith.

14. Shade-tree Management. — Physiology and pathology of shade-trees, as stated in Course 13. Prerequisite, Course 13.

15. Histological Technique. — This course comprises training in general histological methods, including the use of precision microtomes and various methods of killing, fixing, sectioning, staining and mounting of plant materials. This is a technical course in histology, of value to students intending to become research or teaching botanists. It is recommended for students taking Courses 9 and 10, as an aid to the study of relationship between host and parasite, and is open to those taking Courses 13 and 14, who desire to make their studies in tree structure more comprehensive. Collateral reading and conferences. Prerequisites, Botany 2, 3 and 4. Seniors; 3 or 5 2-hour laboratory and conference periods. Credit, 3 or 5.

Associate Professor Osmun.

16. Histological Technique. — As stated in Course 15. Prerequisite, Course 15.

GENERAL AND AGRICULTURAL CHEMISTRY.

Professors Lindsey, Wellington and Chamberlain, Associate Professor Peters, Associate Professor Anderson, Messrs. Bogue, Serex, Robinson, Miller and Gurley.

[The course in chemistry aims to teach accurate observation, logical thinking and systematic and constant industry. It likewise aims to give those students following the several agricultural occupations, or who are preparing themselves for work as teachers and investigators in the other sciences, a knowledge of the subject sufficient to enable them to apply it in their various lines of work. Students taking all of the undergraduate courses and intending following chemistry as a vocation are prepared for positions as instructors in high schools and colleges in the agricultural experiment stations, the United States Department of Agriculture, as well as in fertilizer, cattle food, sugar and dairy industries. Students are encouraged to take graduate work leading especially to the degree of M.Sc., and to thus prepare themselves for advanced positions as teachers in the agricultural colleges, as research chemists, and likewise for the more responsible positions connected with the different agricultural industries of the country. A fuller knowledge of the course of instruction will be found by consulting the following outline.]

Required Courses.

1A. General Chemistry. — An introduction to the fundamental chemical laws, together with a study of the common acid-forming elements and their compounds. Text-book, Kahlenberg's "Outlines of Chemistry." This course is for those students who do not present chemistry for entrance, and who begin the subject in college. Freshmen; lectures, 2 hours; laboratory, 2 hours. Credit, 3.

Associate Professor Peters, Messrs. Bogue and Gurley.

1B. Advanced General Chemistry. — A review of the fundamental chemical laws, together with the common acid and base-forming elements and their compounds. Text-book, Kahlenberg's "Outlines of Chemistry." The laboratory work takes the synthetic form. Substances of agricultural importance are prepared in quantity and studied in detail by the student. These include ammonium sulfate, superphosphate, muriate and sulfate of potash, arsenate of lead, Paris green, Bordeaux mixture, lime-sulfur and emulsions. In addition to these, preparations outlined in Blanchard's "Syn-

thetic Inorganic Chemistry" are made. This course is for students who present chemistry for entrance. Freshmen; lectures, 2 hours; laboratory, 2 hours. Credit, 3.

Associate Professor Anderson, Messrs. Bogue, Gurley, Miller, Robinson and Serex.

2A. General Chemistry. — A continuation of Course 1A. A study of metals and their compounds. The laboratory work is the same as described under 1B.

Associate Professor Peters, Mr. Bogue and Graduate Assistants.

2B. Inorganic Agricultural Chemistry. — A study of the chemical composition, properties and reactions of soils, fertilizers, fungicides and insecticides, and the common materials of construction, such as tile, brick, cements, paints, etc. Text-book, Fraps' "Principles of Agricultural Chemistry." The laboratory work is divided into three parts, as follows: (*a*) qualitative examination of soil, plant ash and superphosphate; (*b*) approximate quantitative determination of moisture, ash, carbonic acid, phosphoric acid, potash, etc.; (*c*) special work on retention of salts by soil, leaching of lime from the soil by carbonated water, etc. Prerequisite, Course 1B. Freshmen; lectures, 2 hours; laboratory, 2 hours. Credit, 3.

Associate Professor Anderson, Mr. Bogue and Graduate Assistants.

Elective Courses.

3. Qualitative Analysis. — *Basic.* — A course in the systematic analysis of metallic salts, presented from the ionic viewpoint. The student studies closely the tests used in the separation and identification of the metals; he then applies these tests to unknown mixtures. Text, Medicus' "Qualitative Analysis," with Böttger's "Qualitative Analysis" and Treadwell-Hall's "Qualitative Analysis" for reference. Prerequisite, Course 2; should be taken, particularly, by all intending to follow chemistry as a vocation. Sophomores; lecture, 1 hour; laboratory, 4 hours. Credit, 3.

Associate Professor Anderson and Mr. Serex.

4. Qualitative Analysis. — *Acidic.* — A continuation of Course 3. A large part of the semester is spent in the examination qualitatively of minerals and of agricultural products. Prerequisite, Course 3. Sophomores; lecture, 1 hour; laboratory, 4 hours. Credit, 3.

Associate Professor Anderson and Mr. Serex.

5. Organic Chemistry. — This course, with Course 6, continues through the junior year. The two courses are designed especially: (1) for those who are looking forward to positions as chemists in agricultural colleges or experiment stations, the United States Department of Agriculture, or similar places, and who need a knowledge of chemistry for itself; and (2) for those who are expecting to enter like positions in other sciences, and who will use their knowledge of chemistry in a secondary way. It consists of a systematic study, both from texts and in the laboratory, of the more important compounds in the entire field of organic chemistry. Especial attention is given to those

compounds which are found in agricultural products or are manufactured from them. These include alcohols, acids, esters, fats, carbohydrates, proteins, etc. The work forms a foundation for courses in physiological chemistry and agricultural analysis, and thus for future work in agricultural chemical investigation. Prerequisites, Courses 1, 2, 3 and 4 (Course 3 or 4 will not be required as prerequisites for those majoring in other courses than chemistry). Juniors; those electing Course 5 are expected to elect Course 6. Lectures, 3 hours; laboratory, 4 hours. Credit, 5.

Professor Chamberlain and Mr. Miller.

6. As stated under Course 5.

[Agricultural Chemistry. — The two following courses in general agricultural chemistry are designed especially for students majoring in the different departments of the Divisions of Agriculture and Horticulture, and every effort is made to meet the demands of these departments. They are for students in practical agriculture, and not for those intending to take up scientific lines of work. They form an alternative group with either Courses 3 and 4 or 5 and 6.]

7. Inorganic Agricultural Chemistry. — The same as Course 2B. This course is designed for those men who have had only Courses 1A and 2A. Prerequisite, Courses 1A and 2A. Juniors; lectures, 2 hours; laboratory, 2 hours. Credit, 3. Associate Professor Anderson and Mr. Serex.

8. Organic Agricultural Chemistry. — The course embraces the study of the most important groups of organic compounds of plants and animals, the composition of plants, the chemistry of plant growth, plants as food and as industrial material, the composition of animals, the chemistry of digestion, absorption and metabolism, animal nutrition, animal foods, rations, etc., and also the study of some of the products related to plants and animals, such as milk, butter, cheese, sugar, alcohol, wood pulp and paper. The treatment of the subject will be general, avoiding (so far as possible) complicated chemical facts and relationships, and endeavoring simply to make the student acquainted with the general chemistry of plants and animals and agricultural processes and products. Prerequisites, Courses 1 and 2. Juniors; lectures, 2 hours; laboratory, 2 hours. Credit, 3.

Professor Chamberlain and Mr. Miller.

9. Quantitative Analysis. — Instruction in this course includes the gravimetric and volumetric determinations of some of the commoner metals and non-metals in minerals and industrial products. Aside from teaching accurate observation and care in manipulation, it is intended for those who would learn the exact methods for determining the elements, particularly, in inorganic substances, and is the forerunner of other courses intended to fit men to become expert analysts. Talbot's "Quantitative Chemical Analysis" is used as a text. Prerequisites, Courses 1, 2 and 3 or 4. Juniors; lecture, 1 hour; laboratory, 8 hours. Credit, 5.

Professor Wellington and Assistant.

10. Agricultural Chemical Analysis. — In this course and Course 11 the methods previously studied, and other approved methods, are applied to the examination of agricultural materials. The analysis of fertilizers, in-

secticides, fungicides and soils is followed by that of cattle foods, dairy products, sugars, starches and allied substances. Prerequisite, Course 9. Juniors; lecture, 1 hour; laboratory, 8 hours. Credit, 5.

Professor Wellington and Assistant.

11. Agricultural Chemical Analysis. — As stated under Course 10. Prerequisite, Course 10. Seniors; lecture, 1 hour; laboratory, 8 hours. Credit, 5. Associate Professor Peters and Assistant.

12, 14 and 16. See below, following Course 15.

13. Physiological Chemistry. — This course is intended to be supplementary to Courses 5 and 6 and Courses 7 and 8. To those who expect to take up scientific work in microbiology, botany, agronomy, animal husbandry, etc., and who have had Courses 5 and 6, it will give acquaintance with the chemistry of the physiological processes in plants and animals, by means of which some of the important organic compounds studied in Courses 5 and 6 are built up in the living organism or are used as food by it. In the lectures the study of food and nutrition as related to both human and domestic animals is the principal subject. In the laboratory, experimental studies are made of the animal body and the processes and products of digestion, secretion and excretion. The course gives additional training in the chemical problems of agricultural experiment station work, especially those connected with investigations in animal and plant nutrition. To those who will not take up scientific lines of work, but will follow practical agriculture, it will give an opportunity for a more detailed study of the chemistry and physiology of problems which were treated generally in Courses 7 and 8. Prerequisites, preferably, Courses 5 and 6 or 7 and 8. Seniors; lectures, 2 hours; laboratory, 2 hours. Credit, 3. Professor Chamberlain and Mr. Miller.

15. Physical Chemistry. — A résumé of general chemistry from the viewpoint of physical chemistry and the application of physical chemistry to agricultural chemistry. Prerequisite, Course 9. Seniors; lectures, 2 hours; laboratory, 2 hours. Credit, 3.

Associate Professor Anderson and Mr. Serex.

[General Statement concerning Courses 12, 14 and 16. — Each student electing either of these courses will be required to take up and follow out some special line of work, the object being to acquaint him with methods of original inquiry. A single concrete example may be found in a comparative study of the different methods for the determination of the several forms of nitrogen. A thesis may not be required, but frequent consultation of the literature bearing on the subject will be necessary. These courses are valuable for all chemists, and particularly so for those intending to take up experiment station work. A student may choose any one but not two of these separate courses.]

12. Special Work in Agricultural Chemical Analysis. — The student is given a problem to solve either in analytical chemistry or related to the agricultural industries. This will acquaint him with the methods used in research and with the literature, and show him how to handle problems in this field of chemistry when occasion arises.

Associate Professor Peters.

14. Special Work in Physiological and Organic Agricultural Chemistry. — In this course, as in Courses 12 and 16, the student will be able to give his attention primarily to one line of chemical study. To those whose tastes and interests are in connection with the organic and physiological problems of agricultural chemistry, many subjects of study present themselves, among which may be mentioned: proteins, carbohydrates, fats, organic nitrogenous compounds in fertilizers and soils and their relation to plants, the commercial production of alcohol from agricultural products, digestion and dietary studies, the chemical study of dairy products, etc. Prerequisites, Courses 5, 6 and 13. Seniors; laboratory, 10 hours. Credit, 5.

Professor Chamberlain.

16. Special Work in Physical Chemistry. — The field of agricultural chemistry offers many problems that have been attacked through the methods of physical chemistry; such, for example, are the hydrolysis of salts and of minerals and the absorption of salts and fertilizers by soils. Each student will select one line of work and follow it through the course, repeating some of the original work. Prerequisite, Course 15. Laboratory, 10 hours. Credit, 5.

Associate Professor Anderson.

18. History of Chemistry. — An exposition of the development of chemical knowledge from the earliest times to the present. Although the entire history will be included, the larger portion of it will receive only brief mention in order that the questions of vital interest in modern life and industry may be studied at greater length. Particular attention will be given to the questions of plant and animal industry. Chemists are strongly advised to take this course. Seniors; lectures, 2 hours. Credit, 2.

Professor Wellington.

ENTOMOLOGY.

Professor Fernald, Associate Professor Crampton, Associate Professor Gates, Mr. Regan, Mr. Martin, ———.

Elective Courses.

1. General and Economic Entomology. — Course 1 comprises a general introduction to the study of insects, including studies on their structure as applied to their identification; the principles of classification; a systematic examination of the different groups and of the most important economic insects of each group, including their life histories and habits, recognition of their work as shown in the collections, and methods for their control. The most important insecticides and their preparation and application are also treated. Students electing Course 1 are expected to take Course 2. Juniors; 3 lecture periods. Credit, 3. Professor Fernald.

2. General and Economic Entomology. — A continuation of Course 1, with laboratory and field work on methods of collecting, preserving and studying insects and their work. Juniors; 2 laboratory or field periods. Credit, 2. Professor Fernald.

3. Advanced Entomology. — This course is subdivided, the time spent on the various subdivisions differing somewhat according to the particular

needs of those taking it; and it is to a large degree given in the form of individual instruction, special attention being paid to the pests attacking the particular crops in which the student is most interested. The student may specialize in fruit pests, market-garden pests, greenhouse pests, field crop pests, etc., to a large extent, in accordance with his plans for future work.

A. Morphology. — Careful studies of the structure of insects belonging to each of the larger and more important orders, together with lectures on the subject, followed by the identification of insects of each of these groups and the study of the collections, to teach the use of the analytical tables and of structural characters in the determination of insects.

B. Histology. — Lectures on the internal anatomy and histology of the various organs, with particular reference to those affected by the various insecticides.

C. Insecticides and Apparatus. — Lectures on the chemistry, preparation and application of the different insecticides, their merits and defects; tests for detecting adulterations; comparative tests of nozzles and other apparatus; and a study of other methods of insect control, together with laboratory work.

D. Coccidology. — Lectures and laboratory work on methods of preserving, mounting and identifying scale insects, particular attention being given to those of greatest economic importance.

E. Bibliography. — Studies of the various entomological publications and of the methods of finding the literature on any insect.

F. Special Studies. — In these studies the insects most closely related to the future occupation of the student will receive attention. The results of these studies are brought together in the form of an essay or thesis; this will include all the essentials of what is known of the life history, habits and injuries caused by each insect studied, together with methods of treatment, and a list of the best articles found in the course of the work. Comstock's "Manual for the Study of Insects" is used in the laboratory work. Seniors; prerequisite, Entomology 2; students electing Course 3 are expected to take Course 4; 1 1-hour lecture period and 3 2-hour laboratory or field periods. Credit, 4.

Professor Fernald, Associate Professor Crampton, Mr. Martin.

4. Advanced Entomology. — As stated in Course 3. Prerequisite, Course 3.

5. Forest and Shade-tree Insects. — A study of the insects injurious to forest and shade trees, and of methods for their control, with laboratory and field work on these insects, and a study of what has been published about them. Seniors; prerequisites, Entomology 1 and 2; 1 lecture and 2 2-hour laboratory or field exercises. Credit, 3. Professor Fernald.

8. Beekeeping. — This course comprises a general consideration of the biology of the honey bee and the elements of practical beekeeping. Some topics covered are: life history, general behavior and instincts, structure, products, relations of bees to plants, the honey flora. The course aims particularly to afford first-hand, practical experience with bees, to the end of enabling their proper maintenance for any purpose, horticultural, educational

or apicultural. Bee diseases, a thorough understanding of which is fundamental, are emphasized. So far as possible the work is made individual in constructing materials and apparatus and in the manipulation of bees. Juniors; seniors may elect. Courses 1 and 2 form a desirable preparation; 2 lectures, 1 2-hour laboratory period. Credit, 3.

Associate Professor GATES and Mr. ——.

10. ADVANCED BEEKEEPING. — This course deals with the advanced and special problems of the beekeeper. Besides considering those difficulties which at present confront the industry, subjects necessarily of limited treatment in the previous course are expanded for the development of particular technique and manipulation. Apiary management, including the principles of queen rearing, are practiced. The course should further qualify for apicultural instruction and inspection service, affording familiarity with the special literature and methods needed in investigation and research. The policy of individual instruction is continued in so far as practicable. Primarily for seniors, but juniors may elect; prerequisite, Course 8; 1 lecture, 1 2-hour laboratory period. Credit, 2.

Associate Professor GATES and Mr. ——.

11. EVOLUTION. — In order to demonstrate the universal scope and operation of the laws of evolution, the course includes a brief sketch of the probable origin and evolution of matter as viewed in the light of modern physical and chemical research; the evolution of the solar system, leading to the formation of the earth; the changes in the earth, preparatory to the production of life; the physical and chemical basis of life; the probable steps in the formation of living matter, and the theories concerning it; the evolution of living things; the appearance of man; his future in the light of his past development; and the evolution of human institutions and ideas. Consideration is also given to the theories concerning the factors of evolution, the general problems of heredity and similar topics. The course closes with a brief discussion of the philosophical, moral and social aspects of the problems involved, and the influence of the idea of evolution upon modern thought. The lectures are supplemented by collateral reading; and a portion of the time is used for the purpose of demonstration, or discussion by the class. Seniors; juniors may elect. Two lecture periods. Credit, 2. Associate Professor CRAMPTON.

MATHEMATICS AND CIVIL ENGINEERING.

Professor OSTRANDER, Assistant Professor DUNCAN, Assistant Professor MACHMER, Mr. HAZELTINE.

Required Courses.

1. HIGHER ALGEBRA. — A brief review of radicals, quadratic equations, ratio and proportion, and progressions; graphs, binomial theorem, undetermined coefficients, summation of series, variation, continued fractions, determinants, permutations and combinations, logarithms, theory of equations. Reitz and Crathorne's "College Algebra." Freshmen; 3 hours a week. Credit, 3.

Assistant Professor DUNCAN, Assistant Professor MACHMER, Mr. HAZELTINE.

2. Higher Algebra. — As stated under Course 1.
Assistant Professor Machmer.

3. Solid Geometry. — Theorems and exercises on the properties of straight lines and planes, dihedral and polyhedral angles, prisms, pyramids and regular solids; cylinders, cones and spheres; spherical triangles and the measurement of surfaces and solids. Wentworth and Smith's "Solid Geometry." Freshmen; required unless accepted for admission; 2 hours a week. Credit, 2.
Assistant Professor Duncan, Assistant Professor Machmer, Mr. Hazeltine

4. Plane Trigonometry (in charge of Department of Physics). — The trigonometric functions as lines and ratios; proofs of the principal formulas, transformations; inverse functions, use of logarithms; the applications to the solution of right and oblique triangles; practical applications. Bowser's "Elements of Plane and Spherical Trigonometry." Freshmen; 3 hours. Credit, 3. Professor Hasbrouck and Assistant Professor Robbins.

Elective Courses.

5. Mensuration and Computation. — The course includes a review of methods of computation, with special emphasis on short and abbreviated processes, together with methods of checking computations and of forming close approximations; use of slide rule. Also the graph, mensuration of plane and solid figures, weights and measures and elementary mechanism. Numerous practical problems are selected from such subjects as the following: the mathematics of woodworking; rough lumber; general construction; forestry methods in heights of trees; pulleys, belts and speeds; power and its transmission; dairying; agronomy; computation of areas from simple measurements. Primarily for juniors; 3 hours. Credit, 3.
Assistant Professor Machmer.

6. Plane Surveying. — The elements of the subject, including the adjustment and use of the usual instruments. Text-book and lectures. Sophomores; 6 hours a week. Credit, 3.
Professor Ostrander, Assistant Professor Duncan, Mr. Hazeltine.

7. Analytic Geometry. — A discussion of the geometry of the line, the circle, of conic sections and of the higher plane curves. Fine and Thompson's "Coördinate Geometry." Prerequisites, Mathematics 1, 2, 3 and 4. Primarily for juniors; 3 hours a week. Credit, 3.
Professor Ostrander.

8. Differential and Integral Calculus. — A first course in the subject, with some of the more important applications. Nichol's "Differential and Integral Calculus." Prerequisites, Mathematics 1, 2, 3, 4 and 7. Primarily for juniors; 5 hours. Credit, 5. Assistant Professor Duncan.

10. Roads and Railroads. — Topographic and higher surveying, highway construction, earthwork, pavements and railroad construction. Text-book and lectures; 6 hours. [Not given in 1914–15.] Credit, 5.
Professor Ostrander.

11. Hydraulics and Sanitary Engineering. — Hydrostatics, theoretical hydraulics, orifices, weirs, pipes, conduits, water supply, hydraulic motors, sewers and sewage treatment. Text-book and lectures; 3 hours. [Not given in 1914–15.] Credit, 3. Professor Ostrander.

12. Elementary Structures. — An elementary course in roofs and bridges. Text-book and lectures; 6 hours. Credit, 5.
Professor Ostrander.

13. Materials of Construction, Foundations and Masonry Construction. — Text-book and lectures; 4 hours. Credit, 3.
Professor Ostrander.

15. Applied Mechanics. — A course in applied mechanics, based on the calculus, with problems. Text-books and lectures. Prerequisite, Mathematics 8; 3 hours. Credit, 3. Professor Ostrander.

MICROBIOLOGY.

Professor Marshall, Associate Professor van Suchtelen, Mr. Itano, [Mr. Davies], Mr. Avery.

[Courses 1 and 3 (= 2 and 4) are especially adapted to those who wish a general, comprehensive, although elementary, survey of agricultural microbiology.]

Elective Courses.

1. Morphological, Cultural and Physiological Microbiology. — Types of micro-organisms, technic of handling, methods of culture and functions of micro-organisms are considered. This course is elementary and fundamental to all applied and special microbiological studies, and therefore is made a prerequisite to all courses offered; 2 hours or 2 credits are assigned to lectures, text-book requirements and recitations; this time will be scheduled. Six hours or 3 credits are assigned to laboratory exercises; only 1 hour of the 6 is scheduled, the remaining 5 hours are arranged with the instructor. Open to juniors and seniors. Credit, 5. The Department.

2. As stated under Course 1, which it repeats.

3. Agricultural Microbiology. — This general comprehensive course is designed to cover in an elementary manner those subjects only which confront the student of general agriculture, — the microbiological features of air, water, sewage, soil, dairy, fermentations, food, vaccines, antisera, microbial plant infections, methods and channels of infections, immunity and susceptibility, microbial infections of man and animals, methods of control or sanitary and hygienic practices. These subjects will be demonstrated by illustrative and typical laboratory exercises, which for each subject, on account of time limitations, must be very elementary and greatly restricted. Prerequisite, Microbiology 1 or 2. Two hours or 2 credits are assigned to lectures, text-

book requirements and recitations; this time will be scheduled. Six hours or 3 credits are assigned to laboratory exercises; only 1 hour of the 6 is scheduled; the remaining 5 hours are arranged with the instructor. Open to juniors and seniors. Credit, 5. The DEPARTMENT.

4. As stated under Course 3.

5. ADVANCED MORPHOLOGICAL, CULTURAL AND PHYSIOLOGICAL MICROBIOLOGY. — The purpose of this course is to prepare the student for a more intimate knowledge of microbiological agricultural problems. To accomplish this object it is necessary to provide more advanced technic and methods of culture, together with a more extensive knowledge of micro-organisms and their functions. Prerequisites, Microbiology 1 or 2, 3 or 4; Chemistry 5 and 6. Six hours or 3 credits are assigned to laboratory exercises; only 1 hour of the 6 is scheduled; the remaining 5 hours are arranged with the instructor. Open to juniors and seniors in the fall and spring semesters. Credit, 3.

The DEPARTMENT.

6. As stated under Course 5.

7. ADVANCED AGRICULTURAL MICROBIOLOGY. — A knowledge of the subjects mentioned in Courses 3 and 4 cannot be obtained without a more extensive training in microbiological practices, as found in Courses 5 and 6. Prerequisites, Microbiology 1 or 2, 3 or 4, and 5 or 6; Chemistry 5 and 6. Six hours or 3 credits are assigned to the laboratory exercises; only 1 hour of the 6 is scheduled; the remaining 5 hours are arranged with the instructor. Open to juniors and seniors in the fall and spring semesters. Credit, 3.

The DEPARTMENT.

8. As stated under Course 7.

9. SOIL MICROBIOLOGY. — Such subjects as the number and development of micro-organisms in different soils; the factors which influence their growth, food, reaction, temperature, moisture and aeration; the changes wrought upon inorganic and organic matter in the production of soil fertility, ammonification, nitrification and denitrification; fixation of nitrogen symbiotically and non-symbiotically; methods of soil inoculation receive attention. Prerequisite, Microbiology 1 or 2. Six hours or 3 credits are assigned to laboratory exercises; only 1 hour of the 6 is scheduled; the remaining 5 hours are arranged with the instructor. Open to juniors and seniors. Credit, 3.

The DEPARTMENT.

10. As stated under Course 9.

11. DAIRY MICROBIOLOGY. — Special emphasis will be placed upon milk supplies. The microbial content of milk, its source, its significance, its control; microbial taints and changes in milk; groups or types of organisms found in milk; milk as a carrier of disease-producing organisms; the value of straining, aeration, centrifugal separation, temperature, pasteurization; the abnormal fermentations of milk; bacteriological milk standards and their interpretation; ripening of milk and cream; the bacterial content of butter; a passing survey of the microbiology of cheeses; a study of special dairy products, as ice cream, condensed milk, artificial milk drinks (the products of microbial actions), represents a list of topics considered. Prerequisite, Micro-

biology 1 or 2, and Dairying 1 (see Dairying 3). Six hours or 3 credits are assigned to laboratory exercises; only 1 hour of the 6 is scheduled; the remaining 5 hours are arranged with the instructor. Open to juniors and seniors. Credit, 3. The DEPARTMENT.

12. As stated under Course 11.

13. FOOD MICROBIOLOGY. — A study of food preservation by means of drying, canning, refrigerating and addition of chemicals will be pursued. Food fermentations, as illustrated by bread, pickles, sauerkraut, ensilage, vinegar, wine, etc., will be examined. Decomposition of foods, as may be seen in meat, oysters, fish, milk, etc., as well as diseased foods, will receive consideration. Contamination of food supplies by means of water, handling, exposure, diseased persons, etc., is of especial significance and will be demonstrated by laboratory exercises. Prerequisite, Microbiology 1 or 2. Six hours or 3 credits are assigned to laboratory exercises; only 1 of the 6 is scheduled; the remaining 5 hours are arranged with the instructor. Open to juniors and seniors. Credit, 3. The DEPARTMENT.

14. As stated under Course 13.

15. HYGIENIC MICROBIOLOGY. — An attempt will be made to select for this course certain material which should be the possession of every individual, and which is basic to public hygiene and sanitation, as applied to man and animals. The microbiology of water supplies, food supplies, vaccines, antisera or antitoxins; the channels by which micro-organisms enter the body, the influence of body fluids and tissues upon them, body reactions with micro-organisms (susceptibility and immunity); the micro-organisms of some of the most important infectious diseases, methods of control, including disinfectants and disinfection, antiseptics, antisepsis and asepsis will be treated. Prerequisite, Microbiology 1 or 2. Six hours or 3 credits are assigned to laboratory exercises; only 1 of the 6 is scheduled; the remaining 5 hours are arranged with the instructor. Open to juniors and seniors. Credit, 3.

The DEPARTMENT.

16. As stated under Course 15.

PHYSICS.

Professor HASBROUCK, Assistant Professor ROBBINS.

[The fundamental and basic importance of the laws and phenomena of physics makes necessary no explanation of the introduction of this subject into the curriculum of an agricultural college. The logical development of the subject emphasizes the importance of physics as a science in itself. Special emphasis is laid, however, on the correlation of the principles studied with the sciences of agriculture, botany, chemistry, zoölogy, thus furnishing an extra tool by use of which the student's work in all the subjects may be more effective.]

Required Course.

1. GENERAL PHYSICS. — General physics covers mechanics of solids, mechanics of fluids, wave motion and heat. These topics are chosen for the required work because they are regarded as the most fundamental of all, and there is no part of the work in physics more necessary for the student who plans to take up practical farming. Course given by text-book and lectures. Sophomores; 4 hours class-room work and 1 laboratory period. Credit, 5. Professor HASBROUCK and Assistant Professor ROBBINS.

Elective Courses.

2. General Physics. — Electricity and light. Text-book, lectures, recitations and laboratory work. Sophomores; 2 hours of class-room work and 1 laboratory period. Credit, 3. Assistant Professor Robbins.

3. Electricity, Heat and Light. — Three-hour lecture and laboratory course open to juniors and seniors; 1 lecture hour and 2 2-hour laboratory periods. Credit, 3. Assistant Professor Robbins.

4. Continuation of Course 3, open to juniors and seniors; 1 lecture hour and 2 2-hour laboratory periods. Credit, 3. Assistant Professor Robbins.

[Mathematics 4 (trigonometry) is, for convenience of grouping, listed under mathematics, although in charge of the Department of Physics.]

VETERINARY SCIENCE.

Professor Paige, Associate Professor Gage.

[The courses in veterinary science have been arranged to meet the needs of students who propose following practical agriculture, and of prospective students of human and comparative medicine.]

Elective Courses.

1. Veterinary Hygiene and Stable Sanitation. — This course is intended to familiarize the student with the relation of water, food, air, light, ventilation, care of stables, disposal of excrement, individual hygiene, etc., to the prevention of disease in farm animals. Juniors and seniors; 3 hours. Credit, 3. Professor Paige.

2. General Veterinary Pathology, Materia Medica and Therapeutics. — In this course such fundamental and general pathological conditions are studied as inflammation, fever, hypertrophy, atrophy, etc., a knowledge of which is essential in the diagnosis, prevention and treatment of disease. The course in pathology is followed by one in materia medica and therapeutics, dealing with the origin, preparation, pharmacology, pharmacy, administration and therapeutic use of the more common drugs. Poisonous plants and symptoms and treatment of plant poisoning are also considered. Juniors and seniors; 3 hours. Credit, 3. Professor Paige.

3. Comparative (Veterinary) Anatomy. — The anatomy of the horse is studied in detail, and that of other farm animals compared with it where differences exist. This course is essential for those students wishing to elect Course 4. Juniors and seniors; 3 hours. Credit, 3. Professor Paige.

4. Theory and Practice of Veterinary Medicine; General, Special and Operative Surgery. — A course intended to familiarize the student with the various medical and surgical diseases of the different species of farm animals. Particular attention is given to diagnosis and first-aid treatment. The student is taught the technic of simple surgical operations that can with safety be performed by the stock owner. This course should be preceded by Course 3, and taken in conjunction with Course 2. Lectures, demonstrations and practice. Juniors and seniors; 3 hours. Credit, 3.

Professor Paige.

5. Essentials of General Pathology. — This course is planned to introduce the student to some of the essential anatomical, histological and general physiological phenomena essential to the understanding of some of the simple general pathological conditions found in domestic animals. Some of the common methods of diagnosis will be considered in the laboratory. The various chemical and biological reactions and tests will be presented from the standpoint of pure science, showing applications of chemistry and biology. The course will serve to liberally educate and stimulate in the student of agriculture the appreciation of some of the methods used in animal pathology for detecting and controlling some of the more common animal diseases. Lectures, demonstration and laboratory work. Juniors and seniors; 2 3-hour laboratory periods. Credit, 3. Associate Professor Gage.

6. Essentials of General Animal Pathology. — This is a continuation of Course 5, and is devoted to a study of some of the common pathological conditions by means of prepared sections, the aim being to demonstrate to the student abnormal animal histological structures commonly observed when material from various cases of animal diseases is prepared for microscopical study. Some of the biological products used in protecting animals against disease will be considered. Juniors and seniors; 2 3-hour laboratory periods. Credit, 3. Associate Professor Gage.

7. Avian Pathology. — A course in poultry diseases. The object of this course is to present information concerning the common diseases of poultry, their etiology, diagnosis and prevention. The work will consist of a systematic study of the diseases of the alimentary tract, liver and abdominal region, followed by a study of the diseases of the respiratory system, circulation and kidneys. The important disease-producing external and internal parasites will be considered; also diseases of the skin and reproductive organs. Lectures and demonstrations. Juniors and seniors; 2 3-hour laboratory periods. Credit, 3. Associate Professor Gage.

8. Avian Pathology. — A continuation of Course 7, devoted to the study of some of the special diseases of poultry. Recent methods used in the control of these diseases will be considered, and opportunity offered the student for demonstrating various disease processes by means of prepared slides. Lectures, demonstrations and laboratory work. Juniors and seniors; 2 3-hour laboratory periods. Credit, 3. Associate Professor Gage.

ZOÖLOGY AND GEOLOGY.

Associate Professor Gordon, Mr. Blanchard.

Zoölogy.

Required Course.

1. Elementary Zoölogy. — This course presents the underlying principles of biology and the zoölogical part of an introductory course. Laboratory dissection and lectures. Sophomores; 1 lecture hour and 2 2-hour laboratory periods. Credit, 3.

Associate Professor Gordon and Mr. Blanchard.

Elective Courses.

3. INVERTEBRATE OR VERTEBRATE ZOÖLOGY. — These are separate courses running throughout the year. The student may elect one or the other, but not both in the same year. The course in invertebrate zoölogy is designed primarily for students who are planning to take up entomology, but is open to any one. The course in vertebrate zoölogy deals with comparative vertebrate anatomy and physiology and is designed for those who desire or require a knowledge of the comparative anatomy and physiology of vertebrated animals. Each course includes laboratory, text-book and lecture work. These courses are scheduled in the junior year, but are open to seniors; hours by arrangement. Credit, 3. Associate Professor GORDON.

4. INVERTEBRATE OR VERTEBRATE ZOÖLOGY. — The continuation and completion of Course 3 of the first semester; hours by arrangement. Credit, 3.
Associate Professor GORDON.

5. ELEMENTS OF HISTOLOGY. — This course gives the theories and methods of preparing normal animal tissues for microscopic examination. Chiefly laboratory work, with reading and occasional seminars. Open to juniors and seniors. Hours by arrangement; see below, Course 6. Credit, 2.
Mr. BLANCHARD or Associate Professor GORDON.

6. ELEMENTS OF HISTOLOGY. — In Course 6 the student may carry forward the work of the first semester, thereby completing a year's work, or may take the work outlined for Course 5. Open to juniors and seniors. Hours by arrangement. Credit, 2.
Mr. BLANCHARD or Associate Professor GORDON.

7. ADVANCED ZOÖLOGY.[1] — Special elective work in advanced zoölogy is offered to seniors who are interested in zoölogy or who are looking forward to advanced work in any department of zoölogy or allied branches; hours by arrangement. Credit, 5.
Associate Professor GORDON and Mr. BLANCHARD.

8. ADVANCED ZOÖLOGY.[1] — This course may be a continuation of the work of the first semester or of separate character; hours by arrangement. Credit, 3. Associate Professor GORDON and Mr. BLANCHARD.

GEOLOGY.

Elective Course.

2. ELEMENTARY GEOLOGY. — Rock-forming minerals; rock types; rock weathering; dynamical, structural and surface geology. Lectures, map and field work. Sophomores; 1 1-hour period and 2 2-hour periods. Credit, 3.
Associate Professor GORDON and Mr. BLANCHARD.

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[1] The work offered in Courses 3, 4, 7 and 8 may apply on a minor for the degrees of master of science or doctor of philosophy.

DIVISION OF THE HUMANITIES.

Professor SPRAGUE.

ECONOMICS AND SOCIOLOGY.

Professor SPRAGUE.

[The courses in Economics and Sociology are planned with the purpose of giving the student that knowledge and understanding of the important factors and problems in this field of study and life which every active citizen and educated man ought to have.]

Elective Courses.

1. POLITICAL ECONOMY. — An introductory course which takes up the study of the nature and scope of economics, the evolution and organization of the present economic system, and the fundamental principles of production, exchange and consumption. The class will study and discuss such topics as wealth, value, capital, interest, profits, wages and labor, tariffs, trusts, etc. Debates on current economic problems will be organized in the class. Text-book, library readings, lectures and discussions. Arranged primarily for juniors; open to seniors; 3 hours. Credit, 3. Professor SPRAGUE.

2. INDUSTRIAL PROBLEMS. — This is a course in the most important industrial problems of the day, covering the methods of organizations of labor and capital, systems of industrial remuneration, means of securing industrial peace, legal status of labor unions and their activities, protective legislation for workmen and employers, the problems of immigration, the sweated industries, prison labor, child labor and industrial education. Text-book, with collateral readings, lectures and discussions; 3 hours. Credit, 3.
Professor SPRAGUE.

4. ANTHROPOLOGY; THE HISTORY OF HUMAN CIVILIZATION. — The evolutionary origin and history of man; characteristics of primitive men, departure from the animal status, and the beginnings of civilization; development of industries, arts and sciences; the growth of languages, warfare, migrations and social institutions; a study of the powerful natural and human forces that have brought man from the early stages to modern conditions; characteristics of the leading races of the world. These topics will constitute the subject-matter of the course. Arranged for sophomores and juniors. Library readings, text-book and lectures; 3 hours. Credit, 3. Professor SPRAGUE.

5. PUBLIC FINANCE, MONEY AND BANKING. — This course follows Economics 1. It will take up taxation and the various systems for collecting public revenue in Europe and America, with the problems involved; the history of money and the systems of banking and finance now in operation; the cause and problems of economic crises and depressions; the currency problems of the United States. For juniors and seniors. Readings, lectures and discussions; 3 hours. Credit, 3. Professor SPRAGUE.

7. SOCIAL INSTITUTIONS AND SOCIAL PROBLEMS. — This course is devoted to the study of the social institutions, such as the family, the church, State and property; and to such current social problems as divorce, race suicide,

crime and prison reform, poverty and its relief. Considerable time is given to the study of eugenics in its social significance and possibilities. The correctional and charitable institutions of Massachusetts are studied in some detail. The later weeks of the term are devoted to a short introduction to sociological theory. Arranged especially for seniors; open to juniors by permission. Readings, lectures, discussions; 3 hours. Credit, 3.

Professor SPRAGUE.

8. MODERN SOCIAL REFORM MOVEMENTS. — The history of property and its vital issues in modern times; the socialistic systems, anarchy and communism; systems of workingmen's insurance in Europe and America, and other methods of relief from the chances of life; educational reforms, in process, to meet the demands of a new age, and legislative remedies for the evils of social change and maladjustment; the crisis of Christianity under modern capitalized industrialism. These topics indicate the nature of the subjects studied. This course is arranged to follow Economics 7; 3 hours. Credit, 3.

Professor SPRAGUE.

HISTORY AND GOVERNMENT.

Elective Courses.

1. ELEMENTS OF POLITICAL SCIENCE. — Nature and scope of political science; origin and evolution of the State; systems of government in the principal European States; organization and working of the national and of the State governments of the United States; relation of government to political parties and to public opinion; the functions of government as related to labor and commerce. [Withheld in 1914–15.] Three hours. Credit, 3.

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2. LOCAL POLITICAL INSTITUTIONS. — A comparative study of the organization, functions and achievements of country and city groups, especially as these are concerned with such matters as taxation, finance, licenses, franchises, public ownership, highways, transportation and communication, water supply, fire protection, public lighting, markets, food inspection, garbage and sewage disposal, infectious diseases, housing conditions, police force, parks and playgrounds, libraries, schools, care of dependents. Three hours. Credit, 3.

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3. THE HISTORY OF NEW ENGLAND. — In this course, New England is regarded as a unit. Although the history of agriculture and of rural life is treated with special fulness, ample attention is given to political, religious and ethical history. It is hoped that the student will not only be led to an intelligent understanding of present economic conditions, but will also be imbued with a progressive loyalty to the highest ideals of the New England of the past. Lectures and required reading; 3 hours. Credit, 3. ————[1]

5. THE HISTORY OF IDEALS. — This course treats history from the idealistic rather than from the economic point of view. It attempts to define

[1] Given in 1914 by Miss Jefferson.

the great ideals which have impelled some of the most important social, political, esthetic, scientific, ethical and religious movements of medieval and modern history, and to trace the causes of the success or failure of the movements to which these ideals have led. Christianity, including monasticism, modern Catholicism and Protestantism; medieval art and architecture; the modern scientific movement; and social and political democracy will be treated historically from this point of view. [Withheld in 1914–15.] Lectures and reading; 3 hours. Credit, 3. ——————

LANGUAGES AND LITERATURE.

Professor Lewis, Associate Professor Neal, Assistant Professor Ashley, Assistant Professor Mackimmie, Assistant Professor Smith, Miss Goessmann. Mr. Harmount, Mr. Julian, Mr. Prince, Mr. Rand.

English.

Required Courses.

1, 2. Freshman English. — Composition; introduction to literature. Recitations, laboratory practice and lectures; theme writing; conferences. Text-book and laboratory manual, Neal's "Thought-building in Composition." Freshmen; 4 hours. Credit, 4.

Associate Professor Neal, Assistant Professor Smith, Mr. Prince, Mr. Rand.

3, 4. Sophomore English. — A general reading course in English literature. Prerequisite, Courses 2 and 3 respectively; sophomores; 2 hours. Credit, 2. Professor Lewis and Miss Goessmann.

Elective Courses in English Language and Literature.

[The elective courses in English fall into two groups. Both groups are intended to increase the student's appreciation of literature as a means to enjoyment, education and spiritual growth. Group one (Courses 11, 12, 13 and 14) will, besides introducing the student to individual writers, emphasize the life and thought of the times, political, economic and social, in order that the student may realize literature as the expression of individual genius representing (by leading it or summarizing it) the thought and spirit of a period or a social unit. Group two (Courses 7, 15 and 16) will tend more to emphasize form-characteristics, artistic quality or historical development of literary types, or individual great writers. Courses 7, 12, 13A, 14A, 15A and 16 are offered in 1914–15 and 1916–17; courses 11A, 12, 13B, 14B, 15B and 16 are offered in 1915–16 and 1917–18.]

7. Advanced Composition. — A. *Working Principles of Writing* (fall of 1914, 1916). — A course introducing the student to the more advanced aspects of general composition. It deals with diction, fundamental processes of phrasing, sentence-structure, the gathering of materials and the organization of thought, and the forms of discourse. In treating the forms of discourse, a good deal of attention may be paid to narration (for argumentation, see Debating). The course is recommended to students who wish to increase either their facility in written expression or their appreciation of language as a means of intellectual and artistic expression. For juniors and seniors; every second year; 3 hours. Credit, 3. Mr. Prince.

B. [Withheld.]

8. [Withheld.]

11. English Writers and Thought. — A. *From Milton to Pope* (fall of 1915, 1917). — A survey course. It begins with a brief review of the Elizabethan period, and then considers the period of Milton (Caroline literature — Puritanism, the civil wars, Cromwell and the Protectorate), followed by the rapidly changing political and social conditions of the Restoration and then of the Revolution, ending with the Augustan age and Pope, and the temporary predominance of classicism and the intellectual instead of emotional qualities in literature. It will, however, emphasize the leading writers of the periods, including Bacon, Milton, Dryden, Addison and the essayists, Swift and Pope. Much of the literature of these times is closely associated with interesting and most important events in English political, religious and social history that introduce and explain the later modern periods. Juniors and seniors; every second year; 3 hours. Credit, 3.

Assistant Professor Smith.

B. [Withheld.]

12. American Writers and Thought. — Intended to give a general survey of literature in America, especially in the nineteenth century, with an introduction to the work of the best-known writers, and with especial attention to the relations between national life and history and national thought as expressed in literature. The usual authors — Irving, Cooper, Bryant, Poe, Longfellow, Emerson, Hawthorne, Whittier, Parkman, Lowell, Holmes, Whitman, Lanier — will be discussed, and attention will be given to southern and western authors. Present writers and tendencies will also receive some notice. Juniors and seniors; every year; 3 hours. Credit, 3.

Mr. Prince.

13. English Writers and Thought. — A. *Verse from 1744 to 1832* (fall of 1914, 1916). — A course in history, appreciation and understanding. Between the years named we see the rapid decline in formalism and a rapid increase of originality, freedom and emotional quality in literature (romanticism), accompanying the appearance in England of liberalism, industrial development, more general education and the spread of the ideals of democracy, and influenced also by Continental thought, especially the spirit of the French Revolution. This is the time in which England entered definitely upon that period of modern struggle, change and reorganization which is to be seen still continuing in contemporary affairs. Some of the writers belonging to it are Thomson, Collins, Gray and Cowper, Goldsmith, Chatterton, Blake, Crabbe, Burns, Coleridge, Wordsworth, Keats, Shelley, Scott and Byron. Juniors and seniors; alternates with Course B; 3 hours. Credit, 3.

Assistant Professor Smith.

B. *Prose from 1744 to 1832* (fall of 1915, 1917). — A course in English prose paralleling Course A, which see. Some of the writers belonging to the period are Johnson, Sterne, Goldsmith, Burke, Miss Burney, Coleridge, Landor, Lamb, De Quincey and Hazlitt. The political essayists and the reviews will receive attention, but prose writers whose principal work was done in the novel will not be emphasized (see Course 15). Juniors and seniors; alternates with Course A; 3 hours. Credit, 3.

Assistant Professor Smith.

14. English Writers and Thought. — A. *Nineteenth Century Verse* (spring of 1915, 1917). — In general conception this course is like Course 13, which see. It begins with literature under the economic and social conditions of Victorian England, involving the advance of democracy, the spread of knowledge and culture, the advance of science, and the increase of industrialism, accompanied somewhat by materialism. The literature of the period takes new forms and directions; among its characteristics is an earnest endeavor to interpret ideals to a vastly increased and incompletely prepared reading public ("social service"). Tennyson, Browning, Mrs. Browning, Arnold, the Rossettis and Morris, Swinburne and Clough are among its noteworthy authors. Contemporary verse-writers will receive some notice. Juniors and seniors; alternates with Course B; 3 hours. Credit, 3.

Professor Lewis.

B. *Nineteenth Century Prose* (spring of 1916, 1918). — This course parallels Course A, which see. Among the writers discussed will be Macaulay, Carlyle, Ruskin, Newman, historians (*e.g.*, Froude) and essayists (*e.g.*, Pater, Arnold and Symonds). Fiction writers are given little attention (see Course 15), but contemporary writers of other prose will be given some notice. Juniors and seniors; alternates with Course A; 3 hours. Credit, 3.

Professor Lewis.

15. Prose Fiction. — A. *The Novel* (fall of 1914, 1916). — The historical development, the technique and the leading types of English novelistic fiction; showing the gradual emergence of specialized forms, the recognition of particular ends that can be served by fiction, and the consequent determination of distinct methods of treatment and classes of material adapted to these ends; and the reading, discussion and criticism of significant works and authors. Among the results that may follow the study of the novel are: (*a*) a sense of critical method, springing from the consideration of historical development and of types; (*b*) a deepened humanism, consequent on the study of acts and motives of men and the influences that modify them; (*c*) increased appreciation of artistic method and form; and (*d*) acquaintance with a kind of literature that has grown into great importance through the popularizing of science, the downward extension of learning, and the democratizing of society. Juniors and seniors; alternates with Course B; 3 hours. Credit, 3.

Associate Professor Neal.

B. *The Short Story* (fall of 1915, 1917). — In this course historical development will be more cursorily treated than in Course A, and emphasis will be placed largely upon the characteristics that are primarily of esthetic and cultural effect — structure, artistry, literary quality, finish, emotional quality, dramatic power. Stories may be read, in translation, from other literatures as well as from English, and students will be encouraged to read freely, although critically, of contemporary work. The course is not one in short-story writing, but students interested in this phase of the subject will be assisted as far as possible. General texts, Neal's "Short Stories in the Making" and "To-day's Short Stories Analyzed." Particular results that may be obtained from short-story study are: (*a*) self-culture, the short story being well adapted to stimulate the literary, dramatic and imaginative faculties;

and (*b*) acquaintance with that type in which American literature has especially succeeded. Juniors and seniors; alternates with Course A; 3 hours. Credit, 3. Associate Professor NEAL.

16. THE DRAMA AND SHAKSPERE. — The source, technique and development of drama, accompanied by a study of Shakspere, his mind, manner and technique. The minor Elizabethan dramatists, their influence on Shakspere, and Shakspere's influence on later writers, will be considered, as will the English social and industrial conditions of the time, their causes and their influence on Shakspere and his fellow writers. Extensive reading, analysis and interpretation of his comedies, tragedies and histories, and of other works, is included. Juniors and seniors; every year; 3 hours. Credit, 3.

Assistant Professor SMITH.

JOURNALISM.

[The courses in journalism emphasize rural journalism. They aim to acquaint the student with the elementary problems and theory of journalism as a profession or vocation, and to exercise him, as far as conditions permit, in the commoner aspects of journalistic work, such as news-gathering, news-writing, desk-editing and editorial writing. By rural journalism is meant the application of journalistic principles in getting and suitably presenting material adapted to the non-urban rather than to the urban or metropolitan reader, so far as their interests are distinct. This includes agricultural journalism, but is by no means confined to that. As practical work, members of the classes have for two years supplied "The Bay State Ruralist," a feature page for the "Springfield Sunday Union." Members of all classes may be required to turn in copy regularly for such disposition as the instructor may determine, and must have free time for covering stories.]

Elective Courses.

1. INTRODUCTION TO JOURNALISM. — The foundation conceptions and aims of journalism; practice in the simple forms of journalistic writing. Prerequisite to all other work in journalism, and valuable also to students preparing for practical farming, agricultural or general science, rural education, etc., as a vocation. Two hours, with a third hour at option of the instructor. Credit, 2. Associate Professor NEAL.

2. NEWS-GATHERING AND NEWS-WRITING. — This includes the gathering and presentation of industrial and agricultural information, campus news or other stories, as may be directed. Courses 1 and 2 are the foundation courses in journalism. Students admitted to 2 who have not had 1 may be required to do supplementary work. Two hours, with a third hour at the option of the instructor. Credit, 2. Associate Professor NEAL.

3, 4. JOURNALISTIC PRACTICE. — The gathering and preparation of material for publication. Prerequisite, Course 1 or 2. At present this course is given only on application, which should when possible be made early in the first year of study. Two hours, with a third hour at the option of the instructor. Credit, 2. Associate Professor NEAL.

5, 6. ADVANCED JOURNALISTIC PRACTICE. — Given only on application. Students may be assigned work as editorial assistants or writers, or otherwise employed in some form of journalistic activity, or directed to the study of particular forms of journalistic writing, of special subjects and their journalistic

presentation, of particular kinds of periodical, or of current topics. The presentation of a thesis may be required. Hours to be arranged. Two hours. Credit, 1. Associate Professor NEAL.

PUBLIC SPEAKING.

Required Courses.

1, 2. FRESHMAN PUBLIC SPEAKING. — Freshman public speaking is required in either the first or the second semester at the option of the instructor. The course is concerned with the actual problems which confront the man who would speak convincingly and persuasively. Some attention is given to breath control and development of speaking voice, considerable attention to pronunciation and enunciation, and a large amount of attention to the preparation and delivery of extempore speeches. Text-book, Shurter's "Extempore Speaking," supplemented by lectures and discussions. Freshmen; in semester 1 or 2 as directed; 1 hour. Credit, 1.

Mr. PRINCE, Mr. RAND.

Elective Courses.

7. DEBATING. — Considerable time is given to the study of argumentation and brief-drawing. The class is divided into teams for the platform discussion of leading questions of the day. This course is designed to develop readiness in extempore speaking. It is recommended for those who desire to enter the intercollegiate debates. Prerequisite, Course 3; 2 hours. Credit, 2.

Assistant Professor SMITH.

8. OCCASIONAL ORATORY. — Exercises for voice and gesture; a study of the elements of vocal expression and action; speeches on assigned topics; prescribed reading; the preparation and delivery of a formal oration or two. It is especially recommended for those who desire to enter the Flint contest. Two hours. Credit, 2. Assistant Professor SMITH.

FRENCH AND SPANISH.

Assistant Professor MACKIMMIE, Mr. HARMOUNT.

FRENCH.

Required Courses.

1, 2. ELEMENTARY FRENCH. — The essentials of grammar are rapidly taught, and will be followed by as much reading as is possible. This course is required of freshmen presenting German for entrance who do not continue that language and have not studied French; open upon arrangement to other students. Freshmen, 4 hours. Credit, 4. Mr. HARMOUNT.

3. INTERMEDIATE FRENCH (third year). — Training for rapid reading; the reading of a number of short stories, novels and plays; composition; reports on collateral reading from periodicals and scientific texts in the library. Required of freshmen who present two years of French for entrance and do not take German, and of sophomores who take Courses 1 and 2 as freshmen; open upon arrangement to other students; 4 hours. Credit, 4.

Assistant Professor MACKIMMIE, Mr. HARMOUNT.

4. Intermediate French. — As stated under Course 3, but not required of sophomores who take Courses 1 and 2 as freshmen. Prerequisite, Course 3.
Assistant Professor Mackimmie.

5. Advanced French (fourth year). — A reading course; Balzac's "Eugenie Grandet" and "Le Père Goriot" and other masterpieces of the nineteenth century; Brunetière's "Honoré de Balzac" and Harper's "Masters of French Literature;" readings in the library and written reports. Required of sophomores who take Courses 3 and 4 as freshmen; open upon arrangement to other students. Prerequisite, Course 4; 3 hours. Credit, 3.
Assistant Professor Mackimmie, Mr. Harmount.

Elective Courses.

6. Advanced French (fourth year). — A general view of the history of French literature; Kastner and Atkins' "History of French Literature." Several plays of the great classical dramatists will be read. Individual conferences on outside reading selected by the student. Prerequisite, Course 5. Sophomores; open upon arrangement to other students; 3 hours. Credit, 3.
Assistant Professor Mackimmie.

7, 8. Scientific French. — This course is planned to meet the requirements of the individual student and aims to equip him with exact English equivalents for the French scientific terms in his particular science. Word lists of scientific terms will be required and also weekly readings and reports from scientific works in the subject in which he is majoring. Several scientific readers will be read. Three hours. Credit, 3. Mr. Harmount.

9, 10. Modern French Literature. — The outline is intended as a suggestion. The exact subject matter of the course will be determined when the men are enrolled. The object of this course is to give an introduction to recent movements in French literature. In the drama, readings from Augier, A. Dumas, fils, Delavigne; in the novel, from Flaubert, the de Goncourts, Zola; in criticism, from Taine, Renan, Sainte-Beuve; for the literary history of the period Lanson's "Histoire de la Litterature Française." Prerequisite, the required French. Juniors or seniors; 3 hours. Credit, 3.
Assistant Professor Mackimmie.

Spanish.

Elective Courses.

1, 2. Elementary Spanish. — Grammar, with special drill in pronunciation; exercises in conversation and composition. Reading from a reader and selected short stories. Intended primarily for juniors. Open to other students upon arrangement. Both semesters; 3 hours. Credit, 3.
Assistant Professor Mackimmie.

3, 4. Modern Spanish Authors. — Reading from modern Spanish novel and drama. Translation of English into Spanish. Private reading. Prerequisites, Courses 1 and 2. Intended primarily for seniors; 3 hours. Credit, 3. Assistant Professor Mackimmie.

GERMAN AND MUSIC.

Assistant Professor Ashley, Mr. Julian.

German.

Required Courses.

1. Elementary German. — Grammar and composition; the reading of short stories, poems, plays, etc. Especial attention is given to oral questioning and answering in German, and to translation of English into German. Required of those presenting French for entrance who do not continue that language and have not studied German. Arranged for freshmen; open by permission to other students; 4 hours. Credit, 4. Mr. Julian.

2. Elementary German. — As stated under Course 1. Prerequisite, Course 1.

3. Intermediate German. — Rapid reading of selected works from Schiller, Goethe, Lessing and others; review of grammar and dictation in German; outside readings. Required of freshmen who present German for entrance and do not take French. Freshmen; open upon arrangement to other students; 4 hours. Credit, 4. Assistant Professor Ashley.

3A. Intermediate German. — Rapid reading of prose works, such as Sudermann's "Frau Sorge," and dramas, such as "Wilhelm Tell" and "Die Journalisten." Required of sophomores who took Courses 1 and 2 as freshmen. Mr. Julian.

4. Intermediate German. — As stated under Course 3. Prerequisite, Course 3.

4A. Intermediate German. — As stated under Course 3A. Open to students who have completed German 3A; 3 hours. Credit, 3.

5. Advanced German. — Literary study of the classicists, — Schiller's "Wallenstein," Lessing's "Nathan der Weise," Goethe's "Iphigenia," etc.; collateral readings in German and class-room reports. Prerequisite, Course 4. Sophomores; required of those who took German 3 and 4 as freshmen; open upon arrangement to other students; 3 hours. Credit, 3.
Assistant Professor Ashley.

Elective Courses.

6. Advanced German. — As stated under Course 5. Sophomores; open upon arrangement to other students. Prerequisite, Course 5; 3 hours. Credit, 3. Assistant Professor Ashley.

7. Scientific German. — Reading in German of modern magazine articles and works of a scientific nature. Different work assigned according to needs of individual students. Open to juniors who have completed Course 4A or more advanced work. Three hours. Credit, 3.
Assistant Professor Ashley.

8. Scientific German. — As stated under Course 7.

9. Conversation and Composition. — Translating connected English into German. Reproducing outside readings in German orally in class; 1 hour. Credit, 1. Assistant Professor Ashley.

10. Modern German. — As stated under Course 9.

11. German Literature. — Advanced language and literary study. Conducted entirely in German. Lectures on German literature and history; life, customs and travel in Germany. Collateral readings, including masterpieces of different epochs, such as "Niebelungenlied," Goethe's "Faust," and one modern typical drama. Prerequisite, Course 6 or 10; 3 hours. Credit, 3. Assistant Professor Ashley.

12. German Literature. — As stated under Course 11.

Music.

Elective Courses.

1. History and Interpretation of Music. — History of music among the ancients; medieval and secular music; epoch of vocal counterpoint; development of monophony opera and oratorio; life and works of the greatest representatives of the classical school — Bach, Händel, Haydn, Gluck and Mozart. One hour. Credit, 1. Assistant Professor Ashley.

2. History and Interpretation of Music. — A continuation of Course 1. The Romantic school; Beethoven, Schubert, Weber, Mendelssohn, Schumann, Chopin, Berlioz and Liszt; Wagner and the opera. The Modern school and Modern composers. One hour. Credit, 1.

Assistant Professor Ashley.

DIVISION OF RURAL SOCIAL SCIENCE.

President BUTTERFIELD.

AGRICULTURAL ECONOMICS.

Associate Professor CANCE, Mr. STRAND.

Required Course.

2. AGRICULTURAL INDUSTRY AND RESOURCES. — A descriptive course dealing with agriculture as an industry and its relation to physiography, movement of population, supply of labor, commercial development, transportation, public authority and consumers' demand. The principal agricultural resources of the United States will be studied with reference to commercial importance, geographical distribution, present condition and means of increasing the value of the product and cheapening cost of production. Lectures, assigned readings, class topics and discussions. Sophomores; 3 hours. Credit, 3. Associate Professor CANCE and Mr. STRAND.

Elective Courses.

3. ELEMENTS OF AGRICULTURAL ECONOMICS. — This course is designed to follow the required work in the elements of economics. It deals with the economic principles underlying the welfare and prosperity of the farmer and those institutions upon which his economic success depends; the economic elements in the production and distribution of agricultural wealth; means of exchange; determination of price; problems of land tenure and land values; taxation of farm property; and the maintenance of the economic status of the farmer. Lectures, text, readings, topics and field work; 3 hours. Credit, 3. Associate Professor CANCE.

5. HISTORICAL AND COMPARATIVE AGRICULTURE. — Recommended to students in journalism or education. A general survey of agriculture, ancient and modern; feudal and early English husbandry; the later development of English agriculture; the course of agriculture in the United States, with special emphasis on the development of agriculture in New England. An attempt will be made to measure the influence of times, peoples and countries in producing different systems of agriculture, and to ascertain the causes now working to effect agricultural changes. Lectures, readings and library work. Seniors and juniors; open to other students upon arrangement; prerequisite, Course 3 or equivalent; 3 hours. Credit, 3.

Associate Professor CANCE.

6. CO-OPERATION IN AGRICULTURE. — The course treats of the history, principles and business relations of agricultural co-operation. (1) A survey of the development, methods and economic results of farmers' organizations and great co-operative movements; (2) the business organization of agriculture abroad, and the present aspects and tendencies in the United States;

(3) the principles underlying successful co-operative endeavor among farmers, and practical working plans for co-operative associations, with particular reference to credit and purchase and the marketing of perishable products. Lectures, text, assigned readings and practical exercises; 3 hours. Credit, 3.

Associate Professor CANCE.

7. THE AGRICULTURAL MARKET. — A study of the forces and conditions which determine the prices of farm products, and the mechanism, methods and problems concerned with transporting, storing and distributing them. Supply and demand, course of prices, transportation by freight, express and trolley, terminal facilities, the middleman system, speculation in agricultural products, protective legislation, the retail market, direct sales and the like are taken up. The characteristics and possibilities of the New England market are given special attention. Lectures, readings, assigned studies and field work. Juniors and seniors; 3 hours. Credit, 3.

Associate Professor CANCE.

8. PROBLEMS IN AGRICULTURAL ECONOMICS. — An advanced course for students desirous of studying more intensively some of the economic problems affecting the farmer. Some of these are: land problems, — land tenure, size of farms, causes affecting land values, private property in land, taxation of farm property; special problems, — cost of producing farm products, farm labor in New England, immigration, shifting of the rural population. Opportunity will be given, if practicable, for field work, and students will be encouraged to pursue lines of individual interest. Seniors and juniors; open upon approval to other students; 2 or 3 hours. Credit, 2 or 3.

Associate Professor CANCE.

9. SEMINAR. — Research in agricultural economics and history: New England agriculture to 1860. Library work and reports. If desirable some other topic may be substituted. Hours to be arranged. Credit, 1.

Associate Professor CANCE.

10. SEMINAR. — As stated in Course 9.

AGRICULTURAL EDUCATION.

Professor HART.

Elective Courses.

1. RURAL SCHOOL PROBLEMS. — Primarily for teachers. A study of agricultural education; the theory and practice of teaching; rural school organization; methods of instruction; the place and function of agriculture in the course of study for both rural and city schools; planning and practical work in school and home gardens; planning of equipment and ornamentation of rural school grounds. One lecture period, and 2 2-hour laboratory periods. Credit, 3.

Professor HART.

2. As stated under Course 1.

3. Meaning of Education (Psychology). — For teachers and others desiring an introduction to mental science. A study of the development, structure and functions of the nervous system and the sense organs; the development and nature of mental activities; the nature of the learning processes. Three lecture periods. Credit, 3. Professor Hart.

4. History and Philosophy of Education. — For teachers and others desiring an introduction to educational theories. A study of educational ideals and movements as exemplified by leading nations and races; the growth of educational institutions as influenced by science and industry; the history and meaning of industrial and agricultural education. Three lecture periods. Credit, 3. Professor Hart.

5. Problems in Rural Education. — For teachers or others interested in special phases of education, such as child development, physical and mental; school organization; rural schools; secondary schools; school programs; grading and promotion of pupils; school grounds and school architecture and equipment; normal schools and the preparation of teachers; agricultural teaching and agricultural schools. Two lecture periods. Credit, 2.
Professor Hart.

6. As stated under Course 5.

7. Graduate Courses. — See Graduate School.

RURAL SOCIOLOGY.

President Butterfield, Professor Hart, Miss Goessmann, Mr. Lund, Mr. Baird.

Elective Courses.

1. The Rural Community. — A broad survey of the field of rural sociology, including such topics as the movements of the rural population, the social conditions and life of rural people, the influence of rural life, the description of the various social institutions of the rural community, an analysis of the fundamental problems of rural life, and the means of developing and redirecting the life of the rural community. Lectures, readings and essays on assigned topics; 3 hours. Credit, 3.
President Butterfield and Mr. Lund.

2. Rural Institutions. — A study of the organized agencies by which rural communities carry on their various forms of associated life; particularly a study of the ways by which the domestic, economic, cultural, religious and political institutions contribute to rural betterment. Special attention given to the rural family and the rural church. Three hours. Credit, 3.
Mr. Lund.

3. The Literature of Rural Life. — A critical and appreciative study of writers, both in prose and poetry, who have interpreted nature from the viewpoint of the lover of country life, and those who have idealized agriculture, horticulture and other rural pursuits, together with those who have upheld as an ideal the development of a rural environment in cities. Three hours. Credit, 3. Miss Goessmann.

4. Rural Law. — The work of this course will cover such points as land titles, public roads, rights incident to ownership of live stock, contracts, commercial paper and distinctions between personal and real property. Text, written exercises, lectures, and class discussions; 1 hour. Credit, 1.

Professor Hart.

5. The State and the Farmer. — A general survey of political organizations and movements among farmers in foreign countries and their influence in shaping agrarian legislation; the character, extent and results of foreign State aid to the farming class; political movements among farmers in the United States; "Granger" legislation; relation of the Department of Agriculture, State boards of agriculture, agricultural colleges and experiment stations, postal system, railway commissions, highway commissions, public health agencies, etc., to rural welfare. [Not given in 1914–15.] Three hours. Credit, 3.

6. Sociological Aspects of Co-operation among Farmers. — An historical sketch of the origin, extent and success of co-operation among farmers in the various European countries and in the United States; personal qualities and social conditions necessary to successful co-operative endeavor; the various forms of co-operative organization viewed in their industrial, intellectual and moral aspects; the influence of co-operation on the farmer's individualism, conservatism, self-help, thrift, contentment and on agrarian legislation, scientific agriculture and farm labor; the relation of co-operation to neighborhood life, to community pride and loyalty, to further associated effort, to class stability, solidarity and status; the demand of co-operation for a new type of leadership; the relation of co-operation to socialism and the competitive system. Three hours. Credit, 3.

8. The Social Conditions of the Rural People. — Composition of the rural population; nature, extent and causes of diseases and accidents; health agencies of control; extent and causes of delinquency and dependency; conditions of temperance, of sexual morality and family integrity; child labor; woman's work and position; relation of employer to employee; standard of living; size of family; cultural ideals; community consciousness and activity; standards of business conduct and of political ethics. Three hours. Credit, 3.

9. The Social Psychology of Rural Life. — Characteristics of the rural mind; character of hereditary and environmental influences; nature and effects of face-to-face groups; psychological effects of isolation, relative security and freedom from strain; relation of contact with nature, of control over immediate environment, of family co-operation and of neighborhood life to self-control, self-expression, sympathy, service and leadership; nature and effects of fashion, conventionality and custom; character of discussion and public opinion, and their relation to class feeling and organization; relation of individualism, conservatism and homogeneity to crowd phenomena and progressive democracy. Three hours. Credit, 3.

Mr. Baird.

10. Farmers' Organizations. — The history, purposes and achievements of the Grange, the Farmers' Union, farmers' clubs, village improvement associations, boys' clubs, etc.; the nature, scope, methods and history of local, State and national associations formed about some farm product or special farm interest, *e.g.*, dairying, horticulture, stock breeding, forestry; their influence on "better farming, better business, better living;" their influence in forming a class consciousness and in shaping legislation; need of federation. Three hours. Credit, 3. Mr. Baird.

11. Sociological Aspects of Current Agricultural Questions. — Government conservation policy, roads, railways, trolleys, telephones, postal service, credit facilities, taxation, pure food laws, tenancy and ownership, intensive versus extensive farming, agricultural labor. Three hours. Credit, 3. Mr. Strand.

13. Seminar. ———————

GENERAL DEPARTMENTS.

MILITARY SCIENCE AND TACTICS.

Captain Martin.

[The Department of Military Science and Tactics conducts its work in conjunction with the Department of Physical Education and Hygiene, in accordance with the following statement: —

All candidates for a degree in a four-years course must take for three years three full hours a week of physical training. This work must be under college supervision. At least two years of the work must be taken in the Department of Military Science and Tactics, in accordance with the requirements of the War Department; the rest is to be taken in the Department of Physical Education.

Under this arrangement, the practical (drill) courses in Military Science are given up to the Christmas recess and from the close of the spring recess to the end of the semester each year; the corresponding courses in Physical Education occupy the intervening time.

Under act of Congress (July 2, 1862), military instruction under a regular army officer is required in this college of all able-bodied male students. Men are excused from the exercises of this department only upon presentation of a certificate given by the college physician; minor disabilities which might bar enlistment are not considered. Students excused from military duty may be required to take equivalent work. The object of the instruction is to disseminate military knowledge in order that in emergency trained men may be found to command volunteer troops; but a further object is to give physical exercise, to teach obedience without detracting from self-respect, and to develop the bearing and courtesy that are as becoming in a citizen as in a soldier. Absences and other offences of military nature, and those of which the military instructor may take cognizance as affecting discipline, are dealt with by the commandant in accordance with the regulations of the department; but delinquencies in theoretical instruction not strictly military in their nature are dealt with in accordance with the rules of the faculty.

Cadets in the graduating class who have shown special aptitude for military service are reported to the Adjutant-General of the United States army and to the Adjutant-General of Massachusetts; in making appointments from civil life to the regular or volunteer army, preference is given to those who have been so reported. The names of the three most distinguished are published in the "Official Register of the United States Army." Assignments to the band are made by the military instructor. Practice in the band is credited in place of drill and theoretical instruction.

The required uniform is of khaki, costing about $18. It is worn by all cadets when on military duty, and may be worn at other times. The uniforms are procured through an authorized tailor. Students upon entering college are required to deposit $18 with the college treasurer to cover the cost of the uniform. The sale of old uniforms is prohibited, unless the consent of the military instructor be obtained.]

Required Courses.

1. Freshman Drill. — Practical instruction in infantry drill regulations through the school of the battalion in close and extended order; advance and rear guards; outposts; marches; ceremonies; guard duty. Upon the conduct and proficiency of this year depends the appointment of corporals for the ensuing year. Freshmen; first semester until Christmas recess; 3 hours. Credit, 1. Captain Martin.

2. Freshman Drill. — As stated under Course 1. Freshmen; second semester after spring recess; 3 hours. Credit, 1.

3. Freshman Tactics. — Theoretical instruction in "Infantry Drill Regulations," to include the school of the company, "Manual of Guard Duty," "Small Arms Firing Regulation." Freshmen; 1 hour. Credit, 1.
Captain Martin.

4. As stated under Course 3.

5. Sophomore Drill. — Practical instruction as before; pointing, aiming and sighting drills; litter drills, and first aid to the injured by detachment; target practice, in gallery and on the range. Corporals are appointed from this class. On their conduct and proficiency depends their appointment as sergeants in the next class. Sophomores; first semester until Christmas recess; 3 hours. Credit, 1. Captain Martin.

6. As stated under Course 5; second semester after spring recess.

7. Sophomore Tactics. — Theoretical instruction in "Infantry Drill Regulations," to include the school of the battalion; advance and rear guards; outposts; marches and ceremonies; "Manual of Field Service Regulations;" preparation of reports; returns, muster-rolls, enlistment and discharge papers, rosters and requisitions, etc.; "Army Regulations;" lectures on military science. Sophomores; 1 hour. Credit, 1. Captain Martin.

8. As stated under Course 7.

9. Junior Drill. — Practical instruction as before, target practice, in gallery and on the range. Sergeants are appointed from this class. On their conduct and proficiency depends their selection as officers for the ensuing year. When necessary, officers will also be appointed from this class. Juniors; first semester until Christmas recess; 3 hours. Credit, 1.
Captain Martin.

10. Junior Drill. — As stated under Course 7; second semester after spring recess.

Elective Courses.

11. Senior Drill. — Practical instruction as before; conduct of drills of lower classes. Officers will as a rule be selected from this class. Cadets electing Courses 11 and 12 must take the election for the year, and not later than the first Monday in June of their junior year. No cadet electing this course will after the commencement drill be permitted to change his election without the consent of the dean of the faculty and of the commandant. Seniors; first semester until Christmas recess; 3 hours. Credit, 1.
Captain Martin.

12. Senior Drill. — As stated under Course 11; second semester after spring recess.

PHYSICAL EDUCATION AND HYGIENE.

Assistant Professor Hicks, Mr. Gore, Mr. Fitzmaurice.

Hygiene.

Required Course.

1. Hygiene. — Lectures, reading, quizzes and a report on some assigned topic of personal hygiene or sanitation. Freshmen; 1 hour. Credit, 1.
Assistant Professor Hicks.

Physical Education.

[The Department of Physical Education conducts its work in physical training in conjunction with the Department of Military Science and Tactics, as explained in the note preceding the description of the courses in Military Science. All classified undergraduate students are given a physical examination upon entering.]

Required Courses.

1. Elementary Gymnastics. — Exercises, games and athletics; from January 1 to April 1, in connection with Course 2. Freshmen; 3 hours. Credit (given only for Course 2), 1. Mr. Gore and Mr. Fitzmaurice.

2. Elementary Gymnastics. — As stated under Course 1.

3. Graded Gymnastics. — Exercises, games and athletics; from January 1 to April 1, in connection with Course 4. Sophomores; 3 hours. Credit (given only for Course 4), 1. Mr. Gore and Mr. Fitzmaurice.

4. Graded Gymnastics. — As stated under Course 3.

5. Gymnastics. — Drills, games and athletics; from January 1 to April 1, in connection with Course 6. Juniors; 3 hours. Credit (given only for Course 6), 1. Mr. Gore and Mr. Fitzmaurice.

6. Gymnastics. — As stated under Course 5.

Elective Courses.

7. Training Course. — History of Physical Education; supervision of indoor and outdoor athletic contests and games; athletic administration. Seniors; 3 hours. Credit, 1. Assistant Professor Hicks

8. Training Course. — As stated under Course 7.

The Graduate School.

The Graduate School.

Kenyon L. Butterfield, A.M., LL.D., President of the College.

Charles E. Marshall, Ph.D., Director of the Graduate School and Professor of Microbiology.

Graduate Staff, 1914–15: Dr. Anderson, Dr. Cance, Dr. Chamberlain, Dr. Fernald, Professor Foord, Professor Graham, Professor Hart, Professor Haskell, Dr. Lindsey, Dr. Marshall, Professor McLean, Professor Nehrling, Professor Osmun, Dr. Paige, Dr. Peters, Professor Sears, Dr. Shaw, Dr. van Suchtelen, Professor Waugh and President Butterfield.

Graduate courses leading to the degrees of master of science and doctor of philosophy have been given for a number of years. Demands for these courses have now greatly increased, and in recognition of the benefits to be derived from a separate organization, a distinct graduate school has been established for the purpose of fitting graduates of this and other institutions for teaching in colleges, high schools and other public schools; for positions as government, State and experiment-station agriculturists, bacteriologists, botanists, chemists, entomologists, horticulturists and zoölogists; and for numerous other positions requiring a great degree of skill and scientific knowledge.

Admission.

Admission to the graduate school will be granted: —

1. To graduates of the Massachusetts Agricultural College.
2. To graduates of other institutions of good standing who have received a bachelor's degree substantially equivalent to that conferred by this college.

In case an applicant presents his diploma from an institution of good standing, but has not, as an undergraduate, taken as much of the subject he selects for his major as is required of undergraduates at the Massachusetts Agricultural College, he will be required to make up such parts of the undergraduate work in that subject as the professor in charge may consider necessary. He shall do this without credit toward his advanced degree.

Admission to the graduate school does not necessarily admit to candidacy for an advanced degree, — students holding a bachelor's degree being in some cases permitted to take graduate work without becoming candidates for higher degrees.

Applications for membership to the graduate school should be presented to the director of the school. Full statements of the applicant's previous training, of the graduate work desired, and of the amount and kind of work already done by him as an undergraduate should be submitted, — together with a statement whether the applicant desires to work for a degree.

Registration is required of all students taking graduate courses, the first registration being permitted only after the student has received an authorization card from the director.

Nature and Methods of Graduate Work.

Persons taking graduate work will find this quite different in its nature from undergraduate courses. A broad knowledge of two (or three) subjects is required, and the professors in charge of these may adopt any methods which may seem desirable to secure this to the student. Lectures, laboratory and field work in various forms are utilized; but whatever the method chosen, the aim is to train the students in methods of original investigation and experiment, inductive reasoning and the ability to carry on independent research. In addition to the lectures, a large amount of outside reading is required, the object being to give a broad knowledge of all aspects of the subjects chosen, in addition to the complete knowledge of those portions involved in or directly related to the original investigation which is to result in the thesis. Originality and ability to lead in scientific research after completing graduate work, and the establishment of a broad and thorough foundation upon which these qualities must be based, are the objects aimed at; and any methods which promise to give these results may be made use of (varying according to the nature and personal equation of each student), the supervision being largely individual rather than collective.

Candidates for the degree of master of science are required to prosecute two subjects, one of which shall be designated as the major and the other as the minor. These subjects may not be selected in the same department.

Candidates for the degree of doctor of philosophy are required to prosecute three subjects, one of which shall be designated as the major, the others as minors. No two of these subjects may be taken in the same department.

Candidates for the degree of master of agriculture are allowed greater privileges in the selection of subjects, but will be required to select a major and such other supporting lines of study as will be necessary to properly equip the individual professionally.

Advanced students who are not candidates for degrees may, with the approval of the faculty of the school, take more than one subject in the same department.

A statement of the subjects chosen must in each case be submitted to the director of the school for approval by the necessary committee. The chosen subjects must bear an appropriate relation to each other.

A working knowledge of French and German is essential to successful graduate work, and students not having this will find it necessary to acquire it as soon as possible after entering.

The graduate staff reserves the privilege of recommending and allowing courses in other institutions as a part of residence instruction. Such supervision will be exercised by the graduate staff and credit granted as are essential to the highest standards of efficiency.

A description of the equipment of the various departments is given under "General Information."

Theses.

A thesis is required of each candidate for an advanced degree. It must be on a topic belonging to the candidate's major subject, must show that its writer possesses the ability to carry on original research, and must be an actual contribution to knowledge.

Two copies of each thesis in its final form, ready for the printer, must be submitted to the director of the school before the candidate for the degree may take the required oral examination. One of the said copies, to contain all drawings, is to be retained as an official copy by the said director, and the other by the department in which the thesis was prepared. The candidate for the doctor's degree must be prepared to defend at the oral examination the views presented in his thesis. When printed, three copies of each thesis must be deposited with the director of the graduate school and three copies with the department in which the work was carried out.

All theses become the property of the department in which they are prepared.

Final Examinations.

For the degree of master of science or master of agriculture, a final examination, which may be either written or oral, or both, is given upon the completion of each subject.

For the degrees of doctor of philosophy or doctor of agriculture, final examinations on the minors taken are given upon the completion of the subjects. In the major subject, a written examination, if successfully passed, is followed by an oral examination in the presence of the faculty of the school.

Degrees conferred.

The degree of master of science and master of agriculture are conferred upon graduate students who have met the following requirements: —

1. The devotion of at least one year and a half[1] to the prosecution of study in two subjects of study and research, not less than one full college year of which must be in residence.
2. The devotion of twenty hours[1] each week to the chief or major subject, and of from twelve to sixteen hours per week to the minor subject.
3. The preparation of a thesis in the major subject, constituting an actual contribution to knowledge, and accompanied by drawings if necessary. The thesis may be waived for the degree of master of agriculture.
4. The passing of final examinations, in both major and minor subjects, to the satisfaction of the professors in charge.
5. The payment of all fees and college expenses required.

The degrees of doctor of philosophy and doctor of agriculture are conferred upon graduate students who have met the following requirements: —

1. The devotion of at least three years to the prosecution of three subjects of study and research in residence at the college.
2. The devotion of twenty hours[1] each week to the chief or major subject during the entire period, and of from twelve to sixteen hours per week for a year and a half to each minor subject.
3. The preparation of a thesis, in the major subject, constituting an actual contribution to knowledge and accompanied by drawings if necessary. For the degree of doctor of agriculture the thesis may be modified to meet professional requirements.
4. The passing of final examinations, in both the major and minor subjects, to the satisfaction of the professors in charge.

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[1] All time statements refer to minimum time.

5. The payment of all fees and college expenses required.

The fee for the degree of master of science is $10, and for the degree of doctor of philosophy, $25.

Courses offered.

Courses available as major subjects for the degree of doctor of philosophy: —

Botany.
Chemistry.
Entomology.
Horticulture.
Microbiology.

Courses available as major subjects for the degree of master of science: —

Agriculture.
Agricultural economics.
Agricultural education.
Botany.
Chemistry.
Entomology.
Horticulture.
Landscape gardening.
Mathematics and physics.
Microbiology.
Poultry science.
Rural sociology.
Veterinary science.

Course available as major subject for the degree of master of agriculture: —

Poultry science.

Courses available as minor subjects for the degree of doctor of philosophy: —

Agriculture.
Agricultural economics.
Agricultural education.
Animal pathology.
Botany.
Chemistry.
Entomology.
Horticulture.
Landscape gardening.
Microbiology.
Poultry science.
Rural sociology.
Zoölogy.

Courses available as minor subjects for the degree of master of science: —

Agriculture.
Agricultural economics.
Agricultural education.
Animal pathology.
Botany.
Chemistry.
Entomology.
Horticulture.
Landscape gardening.
Microbiology.
Mathematics and physics.
Poultry science.
Rural sociology.
Veterinary science.
Zoölogy.

General Outline of Courses for Advanced Degrees.

Agricultural Economics (Major Course). — 1. Graduate research work in agricultural economics will be developed by four principal methods, namely, historical, statistical, accounting and general field investigation. In all instances the method includes facility in investigation, tabulation and interpretation of results.

2. Candidates for the master's degree, or candidates offering a minor in agricultural economics, will be required to pass an examination covering the undergraduate work now offered in agricultural economics, including Course 3, the elements of economics, Course 7, the agricultural market, and

Course 6, co-operation in agriculture; and in addition such definite research work as may be outlined by the department, to consist of original investigations in some particular divisions of the subject of agricultural economics. Courses 6, 7 and 8 are for graduates and undergraduates. Special investigations may be made by electing seminars in agricultural economics.

3. Candidates for the master's degree will be required to write a thesis or a report covering results of a specific line of personal investigation in one or more fields of the subject. Each candidate will also be required to have a working knowledge of the general field of economics, the theory of agricultural economics, the problems of agricultural production, land tenure, land problems, agricultural commerce, agricultural co-operation, statistics of agriculture and prices, and markets and marketing.

Agricultural Education (Major Course). — Courses are available in agricultural education as major or minor subjects for the degree of master of science, or, as a minor subject, for the degree of doctor of philosophy. Study will be pursued along one or several of the following lines: —

1. Massachusetts school legislation.
2. Origin and growth of primary, secondary and higher education in Massachusetts.
3. The origin and growth of normal schools, industrial schools and agricultural schools.
4. Educational literature, fiction, periodicals and reports.
5. The physical and mental development of the individual.
6. School administration.

Animal Pathology (Minor Course only). — 1. Reviews in anatomy.

2. Reviews in organography and histology.
3. Special lectures and readings in general and special pathology.
4. Laboratory studies in general and special pathology.
5. Pathological technique.
6. Conferences.

Botany (Major Course). — The following subjects in botany may be studied: —

(*a*) Plant physiology.
(*b*) Plant pathology.
(*c*) Ecology.
(*d*) History of botany.

In the graduate course in botany special attention is given to such subjects as plant physiology and pathology, ecology and the history of botany, etc. These subjects are pursued to a greater or less extent, as the previous training of the student and the nature of the original problem undertaken may determine. The object of the course is to give the student a technical training in botany to develop the spirit of research and to lay a broad foundation in the subject. (As a supplement to this course the student will do well to take, in addition to his prescribed minor work, a brief course in the history of philosophy and psychology.) Extensive reading of botanical literature, both general and specific, is required in certain subjects, and weekly lectures are given, together with occasional seminars, in which various new problems of botanical science are considered. A thesis dealing with some economic problem in plant physiology or pathology, or in both, and containing a distinct contribution to knowledge, is required.

Chemistry (Major Course). — The department is prepared to offer advanced courses in the following branches of chemistry, particularly as applied to agriculture: —

(*a*) Inorganic chemistry.
(*b*) Organic chemistry.
(*c*) Physiological chemistry.
(*d*) Physical chemistry.
(*e*) Analytical chemistry.

Here follows a statement of courses which may be selected by any one properly qualified, and particularly by those who are desirous of doing work for advanced degrees: —

Course A. — Research in industrial problems applied to agriculture.
Associate Professor Peters.

Course B. — Research in physico-agricultural chemistry. Prerequisite, Course 15 or its equivalent. Associate Professor Anderson.

Course C. — Advanced analytical chemistry. Research work in connection with the study of methods of analysis of fertilizers, cattle feeds, dairy products, soils, insecticides and sugars. Recent and original methods will be applied to a study of the composition of agricultural products.
Professor Wellington or Associate Professor Peters.

Course D. — Advanced organic chemistry. Special topics in advanced organic chemistry will be considered, both by lectures and in the laboratory. These will include such subjects as constitution and properties of carbohydrates, proteins and fats, uric acid and related compounds, and alkaloids; also such purely chemical phenomena as isomerism, tautomerism and optical rotation. The reading will include "The Monographs on Biochemistry," Cohen, Schorlemmer and Lachman. Professor Chamberlain.

Course E. — Advanced topics in physiological agricultural chemistry will be studied especially in the laboratory, including digestion, metabolism and nutrition, dietetics, feeding rations, enzymatic action and isolation of enzymes. Required reading will be followed in Abderhalden, Lusk, Hammersten, Stiles, Armsby and Euhler. Professor Chamberlain.

Lectures on Special Topics. — In addition to the research laboratory courses outlined above, lectures on special topics in organic, analytical and physical chemistry will be given by Professors Chamberlain, Peters and Anderson. These will at present be given in alternate years only. Required of all students majoring in chemistry.

Students for the advanced degrees of master of science and doctor of philosophy, who are taking chemistry as a major, must present as prerequisites all undergraduate courses, 1 to 15 or their equivalent. They will be given a special outline of work, and will also be assigned a subject for an original thesis by the professor in charge. At the end of the work there will be a final written and oral examination before the department. All of this must be completed to the satisfaction of the chemical staff, and particularly of the professor

under whom the work is done. Students not working for a degree may take special work along agricultural chemical lines. Information may be obtained by consulting the chemical staff.

Entomology (Major Course). — I. For the degree of doctor of philosophy as a major: Some knowledge of all the divisions of this subject is essential for the professional entomologist, though a large part of his time will be devoted only to certain portions. To insure some familiarity with all these divisions, lectures, laboratory work, field training or required reading are given in each of the following topics: —

(a) *Morphology.* — Embryology and polyembryony; transformations; histology; phylogeny; hermaphroditism; hybrids; parthenogenesis; pedogenesis; heterogamy; chemistry of colors; coloration; luminosity; deformities; variation.

(b) *Ecology.* — Dimorphism; polymorphism; protective devices; mimicry; psychoses; insect architecture; plant fertilization; insect products; geographical distribution; methods of distribution; migration; geological history; insects and disease; enemies of insects, vegetable and animal; duration of life; experimental entomology.

(c) *Economic Entomology.* — Special methods of control; insecticides; special research; insect photography; methods of preparing illustrations; field work and life-history investigations; insect legislation; methods of record keeping.

(d) *Systematic Entomology.* — History of entomology; classifications and the principles of classification; nomenclature and its rules; how to find and use literature; preparing indices; number of insects known and in existence; lives of prominent entomologists; methods of collecting, preparing, preserving and shipping; important collections; location of types.

(e) *Seminar.* — A monthly meeting of graduates, at which reports on current literature are presented and various entomological topics of importance are discussed.

(f) *Required Readings.* — The best articles on topics named above and on the different orders of insects, in English, French or German, the candidate to be examined at the close of his course on this with his other work.

(g) *Thesis.* — A thesis, illustrated with drawings, consisting of the results of original investigation upon one or several topics, and constituting a distinct contribution to knowledge, must be completed before the final examinations are taken.

II. For the degree of doctor of philosophy as a minor, and for the degree of master of science either as a major or minor: Such portions of the course outlined above as seem most appropriate to their other subjects are given to students taking entomology as a minor.

Horticulture. — Graduate work is offered in various lines of horticulture. For the most part this is divided into the different departments which now constitute the college Division of Horticulture, and which are as follows: pomology, floriculture, landscape gardening, forestry and market gardening. For work in these lines application should be made direct to the heads of the several departments.

Besides this work, however, opportunity is offered for graduate study in general horticulture, including topics from the several organized departments mentioned, and also questions relating to plant breeding, general evolution, propagation, manufacture of horticultural products, etc. This

general work is under the direction of Prof. F. A. Waugh, head of the Division of Horticulture.

Landscape Gardening (Major Course). — Every student before receiving his master's degree with a major in landscape gardening must have given some thorough and fruitful study to each of the following five departments. As far as possible these studies must be of a practical nature, *i.e.*, they must be made upon actual projects in progress of development.

1. *Theory.* — The principles of esthetics as applied to landscape gardening.

2. *Design.* — The principles of pure design and their application in landscape and garden planning.

3. *Construction.* — The practical methods of carrying out landscape plans, laying out, equipment, organization of working force, time and cost keeping, etc.

4. *Maintenance.* — Methods, organization, cost.

5. *Practice.* — Office work, drafting, estimating, reporting, charges, accounting.

Qualifications. — Each student before he may receive the master's degree with a major in this department must convince his instructors that he has a genuine aptitude for some branch of landscape gardening, either in design, construction or management.

Thesis or Project. — Each student, before receiving the master's degree with a major in landscape gardening, must present a satisfactory thesis or complete project. A thesis will consist of a careful original study of some problem in landscape gardening, presented in typewritten form with any necessary illustrations, such as photographs, diagrams, drawings, etc. A project will consist of a completed set of studies of some suitable landscape-gardening problem, such as the design of a park, a real estate subdivision, an extensive playground. Such a project will usually consist of: —

(*a*) Original surveys, including topography.

(*b*) Block plans, showing original design.

(*c*) A rendered plan or plans of the main features.

(*d*) Detailed working drawings.

(*e*) Estimates of cost.

(*f*) Complete report and letter of transmittal.

Minor Course. — Any student electing a minor in landscape gardening will be directed to take such courses from the regular catalogue list as may seem most suitable for him. Under ordinary circumstances no other work will be given to students electing minors. In special cases, however, individual problems will be assigned and individual instruction given. These exceptions will be made in cases where, by so doing, it is possible to give the student material assistance in the plan of his major work.

Microbiology (Major Course). — 1. *Reading.* — Readings will be assigned and reports with critical analyses of literature covering the general subject will be required. For this purpose such material will be selected as will be most pertinent to the needs of the student. Lectures will be given from time to time.

2. *Seminar.* — At intervals the immediate laboratory work and studies of the student will be surveyed and the literature bearing thereon will be discussed. The shaping of investigations in accordance with the critical analyses of the specific literature of the problem involved will be the important rôle of the seminar.

3. *Morphological and Cultural Studies.* — Special advanced studies in the cytology, morphology and cultural characters of micro-organisms will be the general theme of this course. The important factors in classifying and grouping organisms call for an intimate knowledge of this particular phase of microbiology. Laboratory technic will receive emphasis.

4. *Physiological Studies.* — The changes produced by micro-organisms and their functionings in general open a very broad field for investigation and systematic study. It is advised that every graduate student in microbiology give much attention to this branch, gaining thereby the greatest comprehensive knowledge of physiological processes, as well as the methods employed in their determinations.

5. Special advanced courses will be offered in those phases of microbiology indicated by the undergraduate courses: —

1. Fermentation microbiology.
2. Soil microbiology.
3. Dairy microbiology.
4. Food microbiology.
5. Hygienic and sanitary microbiology.

It will be assumed that all graduate students of microbiology must be acquainted with the details of all important phases of agricultural microbiology.

Minor Course. — 1. Courses constituting undergraduate major in microbiology, or their equivalent, will be required.

NOTE. — If the student is familiar with the work of these courses, advanced work will be given in accordance with the graduate major outline.

2. Emphasis will be placed upon that particular phase of microbiology which will be particularly pertinent to the student's major course.

3. Readings will be assigned, and will be reviewed in conferences.

4. Special lectures on selected subjects in microbiology will be given from time to time.

POULTRY SCIENCE (Major Course for the Degrees of M.S.[1] and M.Agr.). — 1. *Reading.* — This course consists of a review of the entire field of poultry literature, covering books, bulletins and special articles. A working index will be required of each student.

2. *Seminar.* — This course consists of a criticism of the most important experiments carried on at the various stations in this and other countries; also a study of poultry conditions in foreign countries, methods of management, etc.; a more detailed study of some of the largest poultry projects in this country.

3. *Anatomy (Gross and Histological), Physiology, Embryology, Pathology and Surgery.* — This course consists of a careful study of the anatomy and physiology of the fowl; also the development of the chick in the shell, not only as an embryological study, but in relation to metabolic processes and heredity. Surgery includes the removal of warts, tumors and similar growths; operating on birds that are crop bound, or have bumble foot or broken legs; also a removal of sexual organs and regrafting the same.

4. *Breeding.* — Longevity, broodiness, size, shape, color of egg, body characteristics, vigor, egg production, etc., are all characters whose relations to heredity are not understood. Breeding projects along these lines are

[1] Original investigations are required of students working for this degree.

a part of this course. The student will also do considerable work in connection with our regular experimental projects.

5. *Feeding.* — This course consists of feeding for color of yolk, feathers, shell, size of egg and chemical variations due to the various feeds; also to determine the relative value of various foods for various purposes.

6. *Brooding.* — This course consists of original work to determine the relation between viability and rate of growth and the following: type of brooder, number of chicks in brood, sanitation, exercise and weather conditions; also a comparison of hen-hatched chicks with those hatched artificially.

7. *Incubation.* — This course includes a study of a large number of perplexing problems of a practical, scientific and mechanical value.

8. *Poultry Diseases.* — This course includes a study of a number of the most important poultry diseases in relation to the rapidity with which they spread and their eradication; also various problems in poultry sanitation.

9. *Thesis.* — This may be either of a scientific or practical nature, or both, and subjects may be chosen from any one of the above courses, except the first and second. (Required of students working for degree of M.S.)

NOTE. — 1. The postgraduate course includes all undergraduate work, together with practical experience. Without the latter, students will be unable to handle Courses 4, 5 and 6.

2. Practical poultry work will be required without credit.

3. Courses 1 and 2 are designed particularly for minors.

RURAL SOCIOLOGY (Major Course). — The scope and character of the work for the degree of master of science in this department are as follows: —

1. All courses included in the department of rural sociology. They are as follows: —

The Rural Community, Rural Sociology 1.
The Literature of Rural Life, Rural Sociology 3.
Rural Law, Rural Sociology 4.
The Social Conditions of the Rural People, Rural Sociology 8.
Sociological Aspects of Co-operation among Farmers, Rural Sociology 6.
Rural Institutions, Rural Sociology 2.
The State and the Farmer, Rural Sociology 5.
The Social Psychology of Rural Life, Rural Sociology 9.
Farmers' Organizations, Rural Sociology 10.
Sociological Aspects of Current Agricultural Questions, Rural Sociology 11.

2. Special study of the three following groups of subjects as related to rural conditions: —

(*a*) Nature, extent and causes of diseases and accidents; health agencies of control; extent and causes of delinquency, and of dependency and the various agencies of amelioration; child labor; woman's work and position; character and status of farm labor.

(*b*) Standards of living; cultural agencies and ideals; moral relations.

(*c*) Community consciousness and social activities; the character of discussion and of public opinion, and the relation of these to class feeling and organization.

3. Selected group of subjects in the following field: —

Some participation in the organization and direction of rural forces. This practical work will be under the direction of the department and in connection with such organizations as rural churches, the United States Department of Agriculture, and the Extension Service of the college.

The student whose minor is in rural sociology will have his work selected largely with reference to his previous preparation and his major subjects.

Veterinary Science. — Work is available in anatomy, hygiene, veterinary pathology, medicine, surgery, parasitology and other special lines or divisions of the subject.

Zoölogy. — Courses in zoölogy are available as a minor for the degree of master of science, and as a minor for the degree of doctor of philosophy. The nature of the work varies according to circumstances, and may be intensive in a special field, or of a somewhat more general character, depending on the student's previous acquaintance with general zoölogical science.

The time devoted to zoölogy as a minor for either of the above-named degrees may vary from twelve to sixteen hours per week, pursued for a year and a half.

List of Students.

A list of the degrees conferred in the Graduate School, and of the students enrolled, is given in the general lists at the end of the volume.

The Short Courses

AND

The Extension Service.

The Short Courses and the Extension Service.

SHORT COURSES.

The short courses offered by the Massachusetts Agricultural College are designed to meet the needs of those who cannot come to the college for the regular academic courses. They furnish the student with instruction in modern, accepted methods, and are made as concentrated and as practical as possible. In the main, the instruction is given by the regular teaching force of the college, the same laboratories and equipment being used as in the regular college work.

The short courses may be grouped as follows: —

A. Winter Schools.
   1. Ten Weeks' Course.
   2. Farmers' Week.
   3. Apple Packing School.
   4. School for Tree Wardens.
   5. Beekeepers' Course and Convention.

B. Summer Schools.
   1. Summer School of Agriculture and Country Life.
   2. School for Rural Social Service.
   3. Conference on Rural Community Planning.
   4. Boys' Agricultural Camps.
   5. Poultry Convention.

C. Miscellaneous Short Courses.
   1. Short Courses for Special Groups (feed dealers, town officials, etc.).
   2. Special Days for Foreigners.
   3. Meetings of Organizations at the College.

Expenses of the Short Courses. — The expense of attending any of the Short Courses is approximately as follows: —

Registration fee (Ten Weeks' Course, Apple Packing School, Summer School),	$5
Furnished rooms in private houses (per week),	$1.50–$3
Board at college dining hall, per week,	$4
Board with private families, per week,	$5–$6

A lunch counter is operated in connection with the college dining hall. Meals may be obtained there *à la carte* at very reasonable prices.

Students in each of the dairy courses must provide themselves with two white wash suits and a white cap for use in the practical dairy work. The cost in Amherst is about $1.25 for suit and cap.

Requirements for Admission to Short Courses. — No entrance examinations are required, but students are advised to review their school work in English and arithmetic. Practical experience in farm, garden, orchard or greenhouse work is an advantage. The courses are open to both men and women.

Students must be at least eighteen years of age and must furnish satisfactory evidence of good moral character. References are required, and these are investigated before applicants are accepted.

A. Winter Schools, 1915.

1. Outline of the Ten Weeks' Courses (January 5 to March 12, inclusive). — The following courses are to be given: —

1. Soil Fertility. Associate Professor Haskell. Three lectures a week.
2. Field Crops. Assistant Professor McDonald. Two lectures and one two-hour laboratory period a week.
3. Types and Breeds of Live Stock. Instructor to be announced. Three lectures and two two-hour judging periods a week.
4. Live Stock Feeding. Instructor to be announced. Three lectures a week.
5. Live-stock Management. Assistant Professor Quaife. One two-hour laboratory period a week.
6. Animal Breeding. Associate Professor McLean. One lecture and one two-hour laboratory period a week.
7. Dairying. Professor Lockwood, Mr. Coons, and Assistants. Five lectures and two two-hour and two three-hour laboratory periods a week.
8. Dairy Bacteriology. Professor Marshall. Two lectures a week.
9. Animal Diseases and Stable Sanitation. Professor Paige. Two lectures a week.
10. Poultry. Professor Graham and Mr. Payne. Five lectures and one two-hour laboratory period a week.
11. Farm Management and Farm Accounts. Professor Foord. One lecture and one two-hour laboratory period a week.
12. Fruit Growing. Professor Sears. Three lectures and two two-hour laboratory periods a week.
13. Market Gardening. Mr. Tompson.[1] Three lectures and two two-hour laboratory periods a week.
14. Landscape Gardening. Assistant Professor Harrison. Two two-hour laboratory periods a week.
15. Floriculture. Associate Professor Nehrling and Mr. Thurston. Five lectures and one field trip a week.
16. Forestry. Professor Clark. One lecture a week.
17. Botany. Mr. McLaughlin. Two lectures a week.
18. Entomology. Professor Fernald. Three lectures a week.
19. New England Rural Life. One lecture a week.
20. Mechanics. Associate Professor Gunness. One two-hour laboratory period a week.
21. Rural Sanitary Science. Professor Marshall. Two lectures a week.
22. Beekeeping. Associate Professor Gates and Mr. Byard. Two lectures and one laboratory period a week.
23. Rural Improvement. Professor Waugh. Two lectures a week.
24. Marketing and Agricultural Economics. Associate Professor Cance. Three lectures a week.

2. Farmers' Week. — In order to reach those who cannot come to the college for a longer time this very practical course, four days in length, is given each year. The regular college equipment is used, and work of the regular faculty is supplemented by lectures and demonstrations by eminent men.

The work is divided into six sections as follows: —

1. Field Crops and Farm Management.
2. Animal Husbandry and Dairying.
3. Poultry Husbandry.
4. Fruit Growing, Market Gardening, Floriculture, Forestry.
5. Women's Section, Home Economics.
6. Community Organization.

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[1] Temporary head of the Department of Market Gardening.

These sections take up the time from early morning until late afternoon. Prominent men are engaged for the evening lectures. Fruit, corn, livestock, dairy and poultry shows, and other exhibits, are among the leading features. No fee is charged. The 1915 Farmers' Week is March 15 to March 19, inclusive.

3. Apple Packing School. — The work of this school, which is conducted by the department of pomology, is of a practical nature, and includes both box and barrel packing. Persons taking the course will become familiar with the various types of packs, and will receive sufficient practice to enable them to do good commercial packing.

4. School for Tree Wardens. — This course is given in co-operation with the State Forester and the Massachusetts Forestry Association, to give tree wardens and city foresters instruction in the planting, care and preservation of trees, forestry practices, spraying, pruning, duties of tree wardens and various phases of civic improvement. The 1915 school will be held March 23 to 26, inclusive. No registration fees are charged.

5. Beekeepers' Course. — In the last few years a complete apiary and equipment has been brought together at the college, under the direction and management of Dr. Burton N. Gates. This equipment furnishes the best of facilities for the teaching of beekeeping and allied subjects. A conference of beekeepers, with extensive exhibits of beekeepers' supplies and apparatus, is held annually at the close of each short course.

The courses offered are: —

1. Practical Phases of Beekeeping. Associate Professor Gates.
2. Crops for Honey Bees. Dr. Brooks.
3. Relation of Bees to the Pollination of Plants. Associate Professor Osmun.
4. Bees and Beekeepers' Supplies. Professor Paige.

The features of the convention are lectures and demonstrations by authorities of national reputation, as well as exhibits of inventors, manufacturers, supply merchants and queen rearers. A special invitation is extended to all beekeepers to display and demonstrate inventions, implements or methods. If table space is desired or special equipment is to be prepared, notice should be sent to Dr. Burton N. Gates, Amherst, Mass. The college provides covered tables for the exhibits.

B. Summer Schools.

1. The Summer School of Agriculture and Country Life. — The Summer School of the Massachusetts Agricultural College will open June 28, 1915, for a term of five weeks. The work of the summer school was designed originally for teachers, and the attendance has been largely of that class. Special attention will be given to the needs of teachers again this year. It has been found, however, that there are many persons who seek a general knowledge of theoretical and practical agriculture, and who can come to the college conveniently during the summer season. Extended courses are offered for the benefit of such persons.

The formal instruction in the summer school is given in definite courses herein described. From these each student may elect not less than 10 nor more than 15 exercises a week, unless a larger or smaller amount of work is allowed by the supervisor. These courses include a large amount of field work, observation trips, outdoor exercises and laboratory experiments.

Besides these, general field exercises are arranged for one afternoon of each week. These are on topics of interest to all. Excursions are arranged for

every Wednesday afternoon, and more extended excursions for the whole school are planned for every Saturday. These excursions are in charge of an instructor. In the past they have proved a very enjoyable feature of the work. Round-table and special discussions are arranged by various instructors as their courses require.

A course of evening lectures on popular topics relating to the work of the school is a feature of the general program. This lecture course is free to all students.

Early registration is desirable. Registration fee for the summer school is $5, payable at the time application is made. No other tuition is charged. This fee should accompany application blank and should be made payable to the Supervisor of Short Courses or the College Treasurer.

2. The School for Rural Social Service. — The Massachusetts Agricultural College offers a School for Rural Social Service in connection with the usual Summer School of Agriculture and Country Life. The courses offered give instruction, furnish information and direct the attention of those interested more particularly to the rural field, which has as yet received little systematic study when compared with that which has been given city conditions.

The courses offered are intended for clergymen, teachers, librarians, town officers, grange workers and others who devote a considerable portion of their time to problems of community development. Courses 35 to 47, inclusive, are designed for the needs of these persons. All other courses given during this period are also open to those who register. There is a registration fee of $1 for those attending this school.

3. The Conference on Rural Community Planning. — This conference is held as a closing feature of the summer school each year. In it the larger problems of New England community development are taken up. The following organizations co-operate with the college in providing the programs: the Massachusetts Federation of Churches, the State Board of Education, the State Grange, the Free Public Library Commission, the Massachusetts Civic League, the State Board of Health, the County Work of the Y. M. C. A., the New England Home Economics Association and the Bureau of Statistics.

Section meetings of these groups are held each forenoon, a general round-table discussion is held each afternoon, and lectures are delivered each evening by persons prominent in social and educational work. Many small group conferences are also arranged.

Extensive exhibits, showing in a graphic way what organizations and communities are doing along welfare lines, are arranged at the time of the conference.

This is a four-day conference and is scheduled for July 27 to 30, 1915. A full program is published about June 1. There are no registration or other fees.

4. Boys' Agricultural Camps. — During the month of July several camps are arranged in order that boys from rural districts and small towns may receive some instruction in agriculture and clean, wholesome sports, and that they may have impressed upon them their responsibilities as coming members of society. The daily program consists of camp duty, flag raising, agricultural lessons, talks on hygiene and good citizenship, play and recreation, instruction in handicrafts, photography, evening camp fires, and lectures by men prominent in boys' work. A small fee is charged to help defray the cost of board and incidental expenses.

5. Poultry Convention. — In order to give a large number of poultrymen, who cannot come to the college for a long period of time, practical instruction in modern methods of breeding, feeding, poultry-house construction, operation of incubators and brooders, selecting and judging poultry for utility and for show, and in marketing poultry products, an annual three-day convention is offered. This will be held from July 21 to 23, 1915, inclusive.

The faculty of the 1914 summer schools was as follows: —

Kenyon L. Butterfield, LL.D., President of the College and Head of the Division of Rural Social Science.
William D. Hurd, M.Agr., Director of the Extension Service and Supervisor of Short Courses.
Herbert J. Baker, B.Sc., Extension Instructor in Farm Management.
John L. Byard, Superintendent of the Apiary.
John R. Boardman, New York City, Lecturer on Rural Leadership.
Jennie Buell, Ann Arbor, Mich., Lecturer, Michigan State Grange.
Alexander E. Cance, Ph.D., Associate Professor of Agricultural Economics.
Joseph S. Chamberlain, Ph.D., Professor of Organic and Agricultural Chemistry.
William D. Clark, M.F., Professor of Forestry.
Laura Comstock, Extension Professor of Home Economics.
Samuel Coons, Instructor in Dairying.
Philip H. Elwood, Jr., B.Sc.Agr., Extension Instructor in Civic Improvement.
R. Hay Ferguson, Extension Professor of Agricultural Economics.
Henry T. Fernald, Ph.D., Professor of Entomology, Chairman of Division of Science.
G. Walter Fiske, LL.D., Oberlin, O., Dean, Oberlin Theological Seminary.
Burton N. Gates, Ph.D., Assistant Professor of Beekeeping.
Harold M. Gore, B.Sc., Assistant in Physical Education.
John C. Graham, B.Sc.Agr., Professor of Poultry Husbandry.
Charles R. Green, B.Agr., Librarian.
F. Josephine Hall, A.M., Waltham, Mass., Adviser for Women.
Sidney B. Haskell, B.Sc., Associate Professor of Agronomy.
Ernst Hermann, Newton, Mass., Director, Playground Association.
Curry S. Hicks, B.Sc., Associate Professor of Physical Education and Hygiene.
Lorian P. Jefferson, A.M., Expert Secretary, Division of Rural Social Science.
Elizabeth Jenkins, Sandwich, Mass., Graduate Student, University of Wisconsin.
William Chauncy Langdon, New York City, President American Pageant Association.
William P. B. Lockwood, B.Sc.Agr., Professor of Dairying.
A. H. MacLellan, Lecturer in Horticulture, MacDonald College, Quebec.
Frederick A. McLaughlin, B.Sc., Instructor in Botany.
John A. McLean, A.B., B.Sc.Agr., Associate Professor of Animal Husbandry.
Kathleen Marsh, Lowell, Mass., Lowell Normal School.
Charles J. Maynard, West Newton, Mass., Author and Lecturer on Bird Life.
Orion A. Morton, Extension Professor of Agricultural Education.
Ezra L. Morgan, A.M., Extension Professor of Community Organization.
Ethel H. Nash, Extension Assistant in Agricultural Education.
Arno H. Nehrling, Associate Professor of Floriculture.
A. Vincent Osmun, M.Sc., Associate Professor of Botany.
Samuel R. Parsons, B.Sc., Instructor, Pennsylvania State College.
Charles A. Peters, Ph.D., Associate Professor of Inorganic and Soil Chemistry.
Edward Tallmadge Root, Boston, Mass., Secretary, Federation of Churches of Massachusetts and Rhode Island.
Frederick W. Ried, Framingham, Mass., Director of Practical Arts, State Normal and Training schools.
Fred C. Sears, M.Sc., Professor of Pomology.
Leone E. Smith, B.S., Scout Master, Boys' Camps.
George E. Stone, Ph.D., Professor of Botany.
Frank A. Waugh, M.Sc., Head of Division of Horticulture and Professor of Landscape Gardening.

A bulletin describing the summer schools is issued in March each year, and may be had upon application to the Supervisor of Short Courses.

C. Miscellaneous Short Courses.

1. Short Courses for Special Groups. — Plans are now under way to provide short courses at Amherst, lasting four or five days, for fertilizer agents, feed agents and dealers, milk inspectors, seed dealers, and other groups desiring such instruction. Information concerning these may be obtained by writing the Extension Service.

2. Special Days for Foreigners. — Each year there are provided at the college special days for foreigners, especially the Polish farmers, of whom there are many in the Connecticut valley. Instruction is given in the phases of agriculture to which this section is best adapted. Instruction is given in soil management, co-operation, American citizenship and history. Similar work among foreigners will be arranged at the College, or in different sections of the State.

3. Meetings of Organizations at the College. — It is customary for the various State organizations of fruit growers, poultrymen, breeders' associations and others to meet for conventions and picnics at the college. Such meetings are welcomed by the college authorities, and organizations are cordially invited to meet at the college. The Extension Service provides facilities for seeing the college grounds, and will assist in arranging programs and other forms of instruction and entertainment.

All requests for announcements or further information regarding any of the short courses should be addressed to the Supervisor of Short Courses, Massachusetts Agricultural College, Amherst, Mass.

THE EXTENSION SERVICE.

Correspondence Courses. — The correspondence courses are offered in response to calls from all sections of the State from people who desire information on agriculture, home economics and country life problems, but who cannot come to the college for it. They are designed to meet the needs of farmers, dairymen, stock breeders, fruit growers, market gardeners, floriculturists, teachers, home makers and all others interested in the farm, the farm home and the rural community.

It is their purpose to present the latest information in such language that all who pursue the study can readily understand the work.

Method of conducting Correspondence Work. — Many books have been written on various agricultural subjects, yet very few are adaptable to the correspondence course work. For this reason the courses consist largely of specially prepared lessons. The subject-matter partakes somewhat of the lectures that are given in the college classes. Certain courses are based wholly on text-books, however, while a number combine both methods. In any case it is recommended that the student purchase one or two books for collateral reading. These can often be obtained from the local library.

The courses are especially recommended to granges, farmers' clubs, Y. M. C. A.'s, and similar organizations. If grange lecturers, club secretaries and other interested persons will organize study classes, and the size of the class or the interest in the subject is sufficient, the supervisor of correspondence courses will gladly meet with the class from time to time to discuss the work and offer suggestions. Below are listed the courses offered for 1915: —

1. Soils and Soil Improvement. Associate Professor Haskell.
2. Manures, Fertilizers and Soil Amendments. Associate Professor Haskell.
3. Field Crops. Assistant Professor McDonald.
4. Farm Dairying. Professor Lockwood.
5. Fruit Growing. Professors Sears, Chenoweth and Mr. Rees.
6. Market Gardening. Mr. H. F. Tompson.
7. Animal Feeding. Mr. Story.
8. Floriculture. Associate Professor Nehrling.
9. Farm Accounts. Professor Foord.
10. Entomology. Professor Fernald.
11. Pedagogy of Agriculture. Professor Fernald.
12. Beekeeping. Associate Professor Gates.
13. Forestry. Professor Clark.
14. Shade Tree Management. Associate Professor Osmun.
15. Gardening and Elementary Agriculture. Extension Professor Morton.
16. Poultry Husbandry. Professor Graham.
17. Home Economics. Extension Professor Comstock.
18. Rural Sociology. Mr. Baird.

Enrollment for Correspondence Courses. — Students may enroll in the courses at any time between October 1 and June 1 of the following year. It has been found advisable to discontinue the courses through the summer months, as farmers and other students cannot devote the necessary amount of time to the lessons at this season.

Expenses of the Correspondence Courses. — In order that none may enroll except those who are interested and desire to pursue earnest study, a small fee is charged. This has been fixed at $1 for each course except Courses 8, 17 and 18, where it has been found advisable to charge $1 for each of the parts. The fee is payable strictly in advance, at the time the enrollment card is sent.

Lectures and Demonstrations. — The members of the faculty of the college are, when other duties will permit, available for lectures and demonstrations before granges, men's clubs, women's clubs, Y. M. C. A.'s, farmers' clubs, boards of trade, and other organizations. A list of more than 40 lecturers and 200 subjects on various phases of agriculture, country life, economics, sociology, education, civic betterment and various scientific subjects has been prepared. Full courses of lectures or single lectures may be arranged.

Organizations arranging the lectures are asked to pay the traveling expenses of the lecturer, provided no admission fee is charged. When admission is charged the lecturer is entitled to a fee in addition to traveling expenses.

Extension Schools. — The extension schools are of two distinct types, the first being the Agricultural Extension School, dealing with the production side of farming and with the problems of the farm home; the second being the Extension School in Community Planning, having to do with the organization and selling end of agriculture and with instruction in the planning and carrying forward of various community activities.

Agricultural Extension Schools. — The college sends a corps of instructors to a town for a five-day school of instruction. At present the following courses are offered: soil fertility, animal husbandry and dairying, fruit growing, poultry husbandry and vegetable gardening for the men, and a home makers' course for the women. Morning and afternoon sessions only are held.

Community Planning Extension Schools. — These schools are arranged to extend over at least three days. The following courses are offered: education, agricultural organization, community program, civic improvement, farm management, town administration, public health, community recreation and

home making. Morning, afternoon and evening sessions are held in these schools.

It is also possible to arrange special extension schools along one line of work, such as fruit growing, dairying, etc.

Communities desiring an extension school make a written request, agreeing to defray all local expenses, such as the rent, heating and lighting of a suitable hall, and the board of the instructors during the school.

Educational Exhibits at Fairs and Other Shows. — The college co-operates with the managers of fairs, industrial expositions, corn shows, poultry shows, fruit shows and other exhibitions by making educational exhibits.

For outside work a large tent has been provided. In this about thirty cabinets containing educational material are arranged. A corps of lecturers and demonstrators accompany the exhibit and give practical instruction daily.

For inside work a space at least 40 by 60 feet is required for this exhibit.

Smaller exhibits along special lines are sent to corn, fruit and poultry shows, milk shows, child welfare exhibits, and so forth.

The managers of fairs and exhibits are required to partially meet the cost of presenting these exhibits.

Educational Trains. — The college, through the Extension Service, will co-operate with railroad and trolley lines in the operation of educational trains and cars. The railroad usually furnishes the means of transportation; the college prepares the exhibit and provides the lecturers and demonstrators.

Extension Work in Special Fields.

Extension Work in Fruit Growing. — This work includes lectures and demonstrations on laying out and planting orchards, pruning, spraying, thinning, grading, packing and marketing fruits. Demonstration orchards, new and renovation plots, are being established all over the State, under a co-operative agreement between the college and the owners of land. Extension schools in fruit growing and fruit grading and packing are arranged on request. Visits to farms for advisory work are made, and correspondence on orcharding subjects is invited.

Extension Work in Animal Husbandry. — This work includes lectures, demonstrations and advisory assistance on subjects pertaining to cattle, horses, sheep and swine, as well as instruction in barn planning. Assistance in organizing dairy improvement associations and breeders' associations is given; stock-judging contests for boys are arranged at the leading fairs.

Extension Work in Dairying. — This includes lectures and demonstrations on the handling and care of milk, cream, butter and cheese; Babcock testing, dairy utensils and dairying manufactures. Educational campaigns may be arranged in different communities, seeking to educate producers, dealers and consumers as to the production and distribution of clean, safe milk.

Control Work in Hog Cholera. — This work is done co-operatively by the college and the United States Department of Agriculture. The work includes lectures upon the disease, demonstrations of inoculation of hogs with the anti-hog cholera serum, inspection of suspected herds and advisory assistance.

Extension Work in Poultry Husbandry. — In addition to conferences at the college and visits to the plants of poultrymen, advice on general poultry

management, diseases, mating, laying out and planning buildings, this work includes co-operative work with State institutions, county schools of agriculture, agricultural departments in high schools, manual training departments in public and normal schools, exhibits of poultry appliances at fairs and shows and other incidental phases.

Extension Work in Farm Management, Field Studies and Demonstrations. — This is carried on co-operatively between the college and the office of farm management of the United States Department of Agriculture at Washington. It consists of a study of farm conditions and farm management problems; instruction in keeping farm accounts and growing field crops; the use of fertilizer and lime; advice as to farm equipment, buildings, and so forth.

Extension Work in Civic Improvement. — This is carried on in connection with the department of landscape gardening at the college. Assistance is rendered in various rural and village improvement enterprises, such as the planting and care of shade and street trees, the planning of playgrounds, school grounds, cemeteries, picnic grounds, the beautifying of water fronts, the rearrangement and development of town commons and reservations of historic interest, and similar activities. Efforts are made to co-operate with local granges, men's and women's clubs, village improvement societies, and like organizations.

Extension Work in Agricultural Education. — This is an organized effort to promote in the public schools of the State the study of agriculture and practical arts relating to country life. This is accomplished by means of conferences with school officials and school patrons, the promotion of agricultural clubs among the school children, and lectures before granges, farmers' clubs and other interested organizations. The work of the agricultural clubs is under the direction of the superintendent of schools or of some one recommended by him. Each town should hold an annual exhibit of products. Exhibits representing rather extensive districts are incorporated with the various agricultural fairs in the State. In this manner elementary instruction in agriculture is promoted by the combined efforts of the public schools, of the patrons of the schools through their agricultural fairs, and of the Agricultural College.

Extension Work in Home Economics. — The Extension Service, through its home economics workers, stands ready to assist in solving problems relative to the household in the same manner as it is endeavoring through other workers to aid in working out problems of the farm. The work includes lectures and demonstrations, assistance in forming girls' clubs and home economics clubs for women, and co-operation with existing organizations in the matter of interesting young people in the proper care of the home.

Extension Work in Community Planning. — A number of communities in the State have appealed to the college for aid in bringing the various organizations in the community to a higher state of efficiency, in order that they themselves might take definite steps toward community development and advancement. The college is now prepared to make scientific studies of communities which lead up, by means of surveys, to the organization of local committees to study the agricultural, educational, religious, transportation, recreation and civic needs of the communities. Several State organizations and some national organizations are usually brought in to aid in working out the plans presented by these committees. Conferences on community affairs

are held upon request. The college acts merely in an advisory capacity, the communities themselves doing the actual organization work.

Demonstration Auto-truck. — In order to reach all communities of the State more effectively, a demonstration auto-truck has been procured. Equipped with spraying apparatus and pruning tools, and with Babcock milk tester and other dairy apparatus, dairy record blanks, farm account blanks, a radiopticon with pictures for illustrative purposes, books, bulletins and pamphlets, this outfit, in charge of a competent instructor or demonstrator, visits towns and farms of the State upon request. The instructor gives lectures and demonstrations appropriate to the agriculture of the community.

Library Extension Work. — This consists principally of loaning to the public libraries of the State general collections of 10 to 30 books and bulletins on agriculture and related subjects. Special collections of smaller size on specified subjects, such as fruit growing, dairying, poultry, beekeeping, home economics, and so forth, are also sent out. These may be kept from four to eight weeks, according to the demand for them. The only expense to local libraries is transportation charge on the books both ways. The college library also supplies, upon request, information regarding books on agriculture and related subjects.

Agricultural Surveys. — To acquire definite information as to existing conditions in rural communities, to be used as a basis for further extension work, agricultural surveys are made. The different organizations and officials in the community, such as the town officers, superintendent of schools and teachers, clergymen, librarians and others, usually co-operate in making such surveys. The survey covers all phases of community life, including soil survey, farm management practices, and the educational, social, religious and recreational life. The inventory is made upon carefully prepared blanks.

Agricultural Co-operation and Marketing. — This work has for its object the establishment of agriculture on a better business basis. Assistance is given in organization of co-operative buying and selling associations, the securing of rural credit, the adoption of better methods of marketing, the establishment of a better market for agricultural produce and other lines of agricultural co-operation.

Massachusetts Agricultural College Agricultural Improvement Association. — This is an organization of ex-students of the college who are now farming in the State and who have banded themselves together for the purpose of promoting the agricultural development of the State by carrying on experiments and demonstrations for the betterment of rural pursuits, by using and encouraging the use of better seeds and animals, by the organization of co-operative societies, and by the dissemination of literature bearing on recent agricultural investigations. Production of high-grade strains of corn and potatoes for the Massachusetts seed trade and work for the improvement of animals are some of their activities.

Demonstration Farms and Plots. — Believing that one of the most effective ways of teaching modern farm practice is by the establishment of demonstrations (not experiments) in all sections of the State, thus showing a man on his own land and under his own conditions the result of proper farm practices, the college is placing demonstration plots throughout the State, showing the proper fertilization for grass and other crops, the results of rotations, the proper care of orchards and dairy management. For several years the Faunce Demonstration Farm has been under the advisory direction

of the college, as is also the Paige farm at Hardwick. The Faunce farm has proved to the Cape Cod region that small fruits, poultry and vegetables can be successfully grown there. Demonstration farms are usually managed by a committee or board of trustees representing the farm and a committee appointed from the college acting jointly.

County or District Agricultural Agents. — As rapidly as State, government and local funds are available, men trained in agriculture are being assigned to counties and districts of the State to act as agricultural agents. Residents of the county or district may, without cost, call upon the agent for assistance upon any agricultural subject. The work is being developed through the co-operation of the United States Department of Agriculture, the college and the community engaging the agent.

Advisory Work with Institutions and Individuals. — Special effort is made to comply with as many of the requests of State institutions and individuals who ask for advice on farm problems as possible. The force of instructors available for this work is at present insufficient to take care of all the demands.

Publications of the Extension Service. — In addition to the regular circulars and bulletins which announce the various short courses and lines of work mentioned, a monthly pamphlet, "Facts for Farmers," giving timely information on agricultural subjects, is issued. Large numbers of helpful circulars and bulletins are annually distributed. Reports of the work of the Extension Service, dairy record blanks, farm account blanks, boys' and girls' club circulars, lists of books, and so forth, may be had upon request.

Co-operation with Other Organizations. — The aim of the Extension Service is to co-operate with existing organizations so far as possible. It is, therefore, glad to work with local organizations, and welcomes suggestions from such organizations as town officers, local granges, farmers' clubs, women's clubs, Y. M. C. A.'s, Y. W. C. A.'s, boards of trade, village improvement societies, teachers, clergymen, librarians and others interested in agriculture and country life.

Information by Correspondence. — Besides the activities mentioned, hundreds are helped through personal visits to farms, and still larger numbers through letters of inquiry, which always receive the most careful attention from every department of the institution.

Student Extension Work. — The Social Service Commission of the college is an organization supported by voluntary subscription. The commission employs an executive officer known as the Social Service Secretary, who, in co-operation with the Extension Service, endeavors to assist the students of the college in doing such extension work as their duties may permit. This consists of lectures and demonstrations on agricultural subjects, teaching English and civics to foreigners, coaching and supervising athletic contests with boys and girls, helping to organize and conduct debating societies and Bible classes, giving talks on true sportsmanship and clean living, giving musical entertainments, and acting as judges and helpers at fairs and other exhibits.

Pamphlets and bulletins are sent free to all who apply for them, and correspondence from any who desire such help as has been mentioned should address the Director of the Extension Service, Massachusetts Agricultural College, Amherst, Mass.

General Information.

General Information.

A. FINANCIAL AND ADMINISTRATIVE.

STUDENT EXPENSES.

Tuition.[1] — Tuition is free to residents of Massachusetts. Students who are not residents of Massachusetts are charged a tuition fee of $40 a year. The tuition charged persons not citizens of the United States is $120 a year. Students entering from Massachusetts are required to file with the president a statement signed by either town or city clerk stating that the applicant's father is a legal resident of Massachusetts; a similar statement is required of those entering from other States.

Beginning Sept. 1, 1915, all students entering the college for the first time as undergraduates or special students will be charged a matriculation fee of $5, which in event of a student leaving the institution shall, if all bills due the college are paid, be remitted, or which shall upon graduation be considered as payment for the diploma.

Dormitories and Board. — The college has dormitory accommodations for about 62 students. The rooms in the dormitories are occupied by the upper classmen, hence new students find it necessary to room in private houses. The rooms in the college dormitories are unfurnished; for the most part they are arranged in suites of three, — one study room and two bedrooms. These rooms are heated by steam and lighted by electricity; they are cared for by students occupying them. The dormitory rent for each person varies from $39 to $66 a year. The rent for furnished rooms in private houses ranges from $1 to $3 a week for each occupant. Correspondence in regard to rooms should be addressed to the dean of the college.

Board may be obtained at the college dining hall. At present the price of board there is about $4 a week. Board is furnished at cost, the price being determined by adding 5 per cent. to the audited rate for the previous three months, and at the end of the period final settlement is made on the basis of actual cost.

EXPENSES.

The necessary college expenses are estimated as follows: —

Tuition: citizens of Massachusetts free; other citizens of the United States, $40 a year; foreigners, $120 a year.

	Low.	High.
Matriculation fee, first year,	$5 00	$5 00
Room in college dormitories or in private houses,	39 00	110 00
Board in college dining hall, $4 a week,	144 00	144 00
Laundry, 50 cents to 85 cents a week,	18 00	30 00
Military uniform, first year,	17 85	17 85
Laboratory fees,	2 00	20 00
Books, stationery and miscellaneous items,	14 15	23 15
	$240 00	$350 00

[1] This statement applies to those registering as regular or unclassified students.

Other Expenses. — Prospective students should understand that the above estimates cover expenses which may be called strictly college expenses, and that there are other financial obligations voluntarily placed upon students which they should expect to meet. Chief among these are class assessments and taxes levied for maintenance of various organizations, such as the Social Union, Athletic Association, weekly publications, etc. Such expenses vary from $15 to $30 a year. Additional financial responsibility is also assumed by students joining a fraternity or entering into other social activities of the college. Students rooming in college dormitories are obliged to equip their own rooms with furniture. The college assumes no responsibility in regard to the safe keeping of student property either during the college term or vacations, except under such special arrangement as may be made with the treasurer. Besides the amount necessary for clothes and traveling, the economical student will probably spend between $275 and $375 per year.

Initial Charges.

At the opening of the college year, before students are registered in their classes, the following charges are payable at the treasurer's office: —

	Freshmen.	Sophomores.	Juniors and Seniors.
Matriculation fee,	$5 00	–	–
Board (if at college dining hall) four weeks in advance,	16 00	$16 00	$16 00
Subscription to "Collegian" (college paper),[1]	1 50	1 50	1 50
Assessment for support of Social Union,	1 50	1 50	1 50
Laboratory fees: —			
Chemistry,	5 00	–	–
Zoölogy,	–	2 00	–
For elective subjects,	–	–	1 00–10 00
Military uniform,	17 85	–	-
Room rent (if in college dormitory),	–	–	19 50–33 00
Student tax for support of athletics,[1]	8 00	8 00	8 00
	$54 85	$29 00	$47 50–$70 00

[1] While this is not essentially a college charge, the treasurer of the college acts as collector for the student activity, and all students are expected to make the payment as indicated. The subscription price of the "Collegian" is fixed by the managers; the amount of athletic tax by vote of the student body.

Laboratory Fees.

The principles observed in establishing laboratory fees are the requirement that students pay for those materials actually used which cannot be supplied by the individual, and that the laboratory fees include a charge sufficient to guard against wanton waste and breakage. Fees may be established for any course without previous announcement. At present, the fees charged are as follows: —

	Per Semester.
Agronomy: —	
Course 3,	$1 50
Course 4,	50
Courses 5 and 6,	1 00
Animal husbandry: —	
Courses 2 and 4,	1 00
Course 7,	2 00
Botany: —	
Courses 2, 3, 7, 8, 9, 10, 11, 12, 13, 14, 15, 16,	3 00
Course 4,	2 00
Course 5,	1 00
Chemistry: —	
Courses 1, 2, 7, 8, 13, 15,	3 00
Courses 3, 4, 5, 6,	4 00
Courses 9, 10, 11, 12, 14, 16,	5 00
Dairying: —	
Courses 1, 2, 3,	1 00
Entomology: —	
Courses 3, 4,	3 00
Landscape gardening: —	
Landscape gardening 1, 2,	2 50
Landscape gardening 3, 4, 7, 8,	3 00
Landscape gardening 6,	1 00
Drawing 1, 2,	2 50
Mathematics: —	
Courses 6, 10,	1 00
Microbiology: —	
All courses, each,	5 00
Pomology: —	
Courses 3, 4,	2 50
Poultry Husbandry: —	
Course 3,	1 50
Course 4,	2 00
Zoölogy: —	
Course 1,	2 00
Courses 3, 4,	4 00

STUDENT AID.

Self Help. — Many students are obliged to find work of some sort to earn their way through college. A few men have met their entire expenses in this manner, many more have paid a large part of their expenses, and many have earned a small proportion of the cost of their college education; but the college recommends that no new student enter without having at least $150 with which to pay his way until he can establish himself in some regular work. The college does not encourage students to enter without money in the expectation of earning their way entirely. The ordinary student will find it better either to work and accumulate money before coming to college, or to take more than four years in completing his college course, or, instead, to borrow money sufficient to carry him through. No student should under-

take work that interferes with his studies, and students should understand that, owing to the large number of applications for employment, no one man can receive a large amount of work at the college. A number of students find opportunities for earning money without depending upon the college to furnish them with work.

So far as possible needy students will be employed in some department of the college. The divisions of agriculture and horticulture usually afford the most work, although there are several permanent janitorships available for students, and sixty or more students are employed at the dining hall. Application for student labor should be made directly to the President. Applicants are required to present statements from parent or guardian and from a selectman or alderman of the town or city in which they reside, showing that the applicant needs assistance. Students whose deportment or class work is not satisfactory are not likely to be continued in student labor. The most desirable and responsible positions are naturally assigned to those needy students who have been in the institution longest and who have demonstrated their need and ability. Students, therefore, may find it rather difficult to obtain all the work they desire during their freshman year; as a matter of fact, however, any student who is capable of doing a variety of things, and who is a competent workman, usually finds little difficulty in obtaining all the work that he can do from the outset.

Special Notice to Needy Students. — In the last few years the demand for paid labor on the part of new students has far exceeded the amount of employment that the college can offer. The college cannot promise work to any student, particularly to freshmen; it accordingly urges prospective students who are dependent entirely upon their own efforts not to undertake the course before they have earned enough money to carry them through, or nearly through, the first year.

STUDENT ACCOUNTS.

The following rules are enforced concerning student accounts: —

No student will be allowed to graduate until all bills due the institution from him are paid.

College charges, such as room rent, laboratory fees and tuition, must be paid in advance, at the beginning of each semester. This rule is strictly adhered to, and no student will be allowed to register in his class until such payments are made.

Every student boarding at Draper Hall is required to pay at the beginning of each semester at least one month's board in advance; and no student will be allowed to continue to board at Draper Hall if at any time during the semester he is more than one week in arrears in his payment for board.

All money due for student labor shall at the discretion of the treasurer of the college be applied on account toward any bills that a student may owe to the institution.

STUDENT RELATIONS.

The customary high standard of college men in honor, manliness, self-respect and consideration for the rights of others constitutes the standards of student deportment.

Any student known to be guilty of dishonest conduct or practice must be reported by the instructor to the President for discipline.

The privileges of the college may be withdrawn from any student at any time, if such action is deemed advisable.

It should be understood that the college, acting through its President or any administrative officer designated by him, distinctly reserves the right not only to suspend or dismiss students, but also to name conditions under which students may remain in the institution. For example, if a student is not doing creditable work he may not only be disciplined but he may also be required to meet certain prescribed conditions in respect to his studies, even though under the foregoing rules his status as a student be not affected. The same provision applies equally to the matter of absences ("cuts"). According to the rules a student is allowed a certain percentage of absences from class and other exercises. This permission, which implies a privilege and not a right, may be withdrawn at any time for any cause.

Similarly, also, it applies to participation in student activities. Though this will ordinarily be governed by the rules as already laid down, yet, if in the judgment of the college authorities a student is neglecting his work on account of these activities the privilege of participating in them may be withdrawn for such time as is considered necessary. Moreover, it may be withdrawn as a punishment for misconduct. Prospective students or their parents may, upon application, obtain a copy of the faculty rules governing student relations to the college.

B. COLLEGE ACTIVITIES.

GENERAL EXERCISES.

Chapel exercises are as a rule held four mornings each week. On Wednesday, instead of chapel an afternoon assembly is held, to which some prominent layman or professional man is invited to speak. The object of these assemblies is to bring to the students discussions of topics of present-day interest. A special chapel service on Sunday is usually held during the winter months. Students are required to attend these general exercises, although the President is authorized to excuse from chapel any student who may object to attendance thereon because of his religious scruples, provided his request for excuse therefrom is endorsed by his parent or guardian.

STUDENT ACTIVITIES.

A large number of student organizations furnish opportunity to students for work and leadership.

The Massachusetts Agricultural College Social Union was established about six years ago. All students become members of the Union by paying a small fee. The Union is designed to become the center of student interests. In North College it has a trophy room and a large lounging room for music, reading and study; in the basement of this building there is also a game room for pool and billiards. In the fall and winter months the Union gives a series of entertainments, free to students and faculty.

The College Senate is composed of representatives of the junior and senior classes. This body serves as a general director of undergraduate conduct, and represents before the faculty the interests of the student body.

The M. A. C. Christian Association is active both socially and religiously. Under its direction voluntary Bible classes are conducted during the winter months. A Catholic Club has also been organized.

The musical organizations include an orchestra, a mandolin club and a glee club. These furnish music for college meetings, and occasionally give concerts at the college and at other places. A military band is maintained as part of the cadet corps.

A Dramatic Club has been organized, and each year presents a play.

The Press Club, organized in 1913–14, has headquarters in the English-Journalism room, but is soon to have a news room of its own in North College.

The Public Speaking Council represents the students' interest in debate and oratory.

The Athletic Association represents in the college the interests of football, baseball, track, hockey and tennis.

A Rifle Club has been organized for a few years. Teams representing this club have repeatedly won the intercollegiate championship of the country, both in indoor and outdoor contests.

The college publications are the "Massachusetts Collegian," published weekly by the student body, and the "Index," published annually by the members of the junior class.

The Stockbridge Club is an organization of students especially interested in practical agriculture and horticulture. Regular meetings are addressed by outside speakers, and members present papers and engage in discussions.

Scientific clubs also exist in the departments of French, entomology, landscape gardening and zoölogy.

There has recently been organized a Collegiate Country Life Club, the membership of which is composed of faculty and students who are particularly interested in the study of country life problems.

C. ACADEMIC AND DEPARTMENTAL.

DEGREES.

Those who complete a four-year course receive the degree of bachelor of science. The fee for graduation from the college is $5.

Graduate students who complete the assigned courses will receive the degree of master of science upon the payment of a fee of $10. Credit may sometimes be allowed towards this degree for teaching or other advanced work done in some department of the college.

Graduate students who complete the required three-year course of study, and present a satisfactory thesis, will be granted the degree of doctor of philosophy.

Those to whom degrees are awarded must present themselves in person at commencement to receive them. No honorary degrees are conferred.

The honorary fraternity of Phi Kappa Phi has a chapter at the agricultural college. Students are elected to membership to this fraternity on the basis of scholarship. Elections are made from the highest fifth of the senior class who have attained an average grade of at least 85 per cent. during their college course.

PRIZES.

Prizes are given annually in several departments for excellence in study or for other special achievement. Prizes offered in 1914 were: —

Agriculture. — The Grinnell prizes (first, second and third), given by the Hon. William Claflin of Boston in honor of George B. Grinnell, Esq.,

of New York, to those members of the senior class who pass the best, second best and third best examinations, oral and written, in theoretical and practical agriculture. They are $25, $15 and $10.

ANIMAL HUSBANDRY. — The F. Lothrup Ames Prize, given by F. Lothrup Ames, Langwater Farms, North Easton, Mass., consisting of $150 a year, offered for a period of five years, beginning 1912, to be given to the three students standing highest in the work of advanced live-stock judging, and to be used in defraying their expenses incurred by participation in the students' judging contest at the National Dairy Show, Chicago.

BOTANY. — The Hills prizes, given by Henry F. Hills of Amherst, amount to $35 annually. Competition is open to members of the senior, junior and sophomore classes as follows: for the best herbarium, $20; for the second-best herbarium, $15. No collection deemed unworthy of a prize will be considered.

ENTOMOLOGY. — In 1914 a special prize of $5 was offered to that member of the junior class presenting the best collection of insects.

GENERAL IMPROVEMENT. — The Western Alumni Association prize ($25) is given to that member of the sophomore class who, during his first two years in college, has shown the greatest improvement in scholarship, character and example.

PUBLIC SPEAKING. — The Burnham prizes are awarded as follows: to the students delivering the best and second best declamations in the Burnham contest, $15 and $10, respectively. The preliminary contests in declamation are open, under certain restrictions, to freshmen and sophomores.

The Flint prizes are awarded as follows: to the students delivering the best and second best orations in the Flint contest, a gold medal and $20 and $15, respectively. The preliminary contests in oratory are open, under certain restrictions, to all regular students.

The prizes in debate are awarded as follows: to each of the three students ranking highest in the annual debating contest, a gold medal and $15. The preliminary contests in debate are open, under certain restrictions, to all regular students.

EQUIPMENT.

AGRICULTURAL EDUCATION. — The courses in this department are planned primarily for those who are preparing to teach. The work is carried on by means of lectures, library and demonstrations. The department has an office, lecture room and a laboratory in the Veterinary Science building. The laboratory is equipped with a balance, dishes, jars, reagent bottles, test tubes, petri dishes, lenses, a Babcock test, a Wisconsin sediment test, Bunsen burner, hot and cold water, electricity, gas and other appliances for giving demonstration and practice lessons in Secondary Agriculture. There is also equipment for conducting children's gardens on the campus. Instruction in school gardens constitutes a part of the practice work of those training for the occupation of teaching. Some practice work in teaching is done in the grammar grades of the Amherst schools, and in the agricultural departments of Hopkins' Academy, and Smith's Agricultural School at Northampton. This department is also intimately related to the matter of recommending candidates for teachers' certificates. At least four courses in the department are required of students preparing for such certificate. The office is supplied with school and college reports, also a large number of pamphlets and bulletins

relating to the subject of agriculture in the schools, courses of study, etc. See note relative to teachers' certificates, under major in Agricultural Education.

Agronomy. — The work in agronomy is carried on by means of lectures, laboratory work and field work. The laboratories are in the north wing of South College. The seed laboratory is equipped with samples of the different grains and seeds of plants of economic importance in field culture, and with apparatus for the study and testing of these seeds, including microscopes and the apparatus necessary for viability and purity tests. The soil laboratory is equipped with apparatus for studying the physical properties of soils, and with tools used in the reclamation of land by drainage and by irrigation. A large part of the work is done in the field, the college farm being used as a laboratory.

Animal Husbandry. — An accurate and definite knowledge of the market types and grades, and of the various breeds of live stock, is fundamental to the work of this department. The department is equipped with an excellent laboratory, Grinnell Arena, which has a seating capacity of 180, and which is fully adapted to the requirements. There are upwards of 125 head of dairy cattle of various ages available for class-room work; among these are included superior representatives of the Jersey, Guernsey, Ayrshire and Holstein breeds. There are flocks of pure-bred Shropshire and Southdown sheep of the best breeding and individuality. Considerable numbers of pure-bred Berkshire and Yorkshire pigs are maintained. The college possesses pure-bred Percherons and French coach horses, besides many work teams of different types, which are available for class-room purposes. A set of plaster of Paris models of individuals of foreign and domestic breeds of horses, cattle, sheep and swine, and a collection of the different foodstuffs available for the use of the New England farmer, are included in the equipment for this work. An excellent set of upward of 250 lantern slides, portraying the leading prize-winning, producing, and breeding animals of the leading breeds, — horses, cattle, sheep and swine, — belongs to this department, and is regularly used in instructional work. This equipment is being added to from time to time as funds are available.

Botany. — The department of botany occupies Clark Hall, a brick building 55 by 95 feet, two stories high, with basement and attic. It has two lecture rooms, one seating 154 and the other seating 72 people; one seminar and herbarium room; a large laboratory for sophomore and junior work, and one for senior work; and three rooms specially fitted for graduate students. The experiment station laboratories devoted to botanical research are also in this building. A small museum contains material especially useful in the teaching and illustration of plant phenomena; and on the third floor is a collection of Massachusetts timber trees, specimens showing peculiar formations of plant growth, and various specimens illustrative of scientific methods of treating trees.

The laboratories and lecture rooms are of modern construction, finely lighted and supplied with all necessary conveniences. The basement contains a bacteriological laboratory, a seed and soil room; and a convenient workshop provided with benches for wood and metal work, an electric motor, a power lathe, and other tools and appliances. In the senior laboratory is a room designed especially for physiological work; this laboratory is well supplied also with apparatus for the study of simple phenomena in plant

physiology, such as respiration, metabolism, transpiration, heliotropism, etc. The herbarium contains 18,000 sheets of flowering plants and ferns, 1,200 sheets of mosses, 1,200 sheets of lichens and liverworts, and about 20,000 specimens of fungi. The laboratory is equipped with 94 modern compound microscopes and a number of dissecting microscopes, microtomes and a large series of charts. A conservatory 28 by 70 feet is connected with the laboratory. This is designed for experiment work and for housing material often needed in the laboratory.

Chemistry. — The college department of chemistry occupies the entire building previously known as the "old chapel." The basement is used for the storage of apparatus and chemicals. The first floor contains large laboratories devoted to organic, physiological and physical chemistry, and qualitative analysis. The second floor is occupied by the general lecture room, by offices for the several members of the staff and by laboratories for analytical chemistry. The third floor has been fitted for work in general chemistry, and has desk room and hoods sufficient to accommodate 66 students at one time. Each place is supplied with reagents and apparatus for independent work. This floor is also occupied by a lecture room that will seat 100 students.

The entire laboratory is well equipped with the necessary apparatus and chemicals for all students who desire to perfect themselves as expert chemists, or who wish to study chemistry as a supplement to some other line of practical or scientific work. The equipment includes a valuable and growing collection of specimens and samples of minerals, soils, raw and manufactured fertilizers, foods, milk products, fibers, various other vegetable and animal products and artificial preparations of mineral and organic compounds; and also a series of preparations for illustrating the various stages of different manufactures from raw material to finished product.

Dairying. — The dairy work is given in Flint Laboratory, a new building, designed for the dairy department. It contains large, well-lighted, sanitary and well-equipped laboratories. The equipment is new and of the best types of market milk and farm dairy machines.

Dining Hall. — Draper Hall, a brick colonial building, equipped with the modern conveniences of a dining hall, was opened in 1903. The dining service is under the supervision of the college. The building contains a limited number of rooms for young women students.

Drawing. — The class in drawing occupies a room on the second floor of Wilder Hall. It is equipped with tables and adjustable drawing stands. The necessary materials and implements are provided. The equipment includes drawing models, and plaster casts of leaves, flowers, fruits, human and architectural details, and garden ornaments, two universal drafting machines, an eidograph, centrolineads, a set of ship splines and French curves, complete water-color outfits, automatic crosshatchers and protractors.

Entomology. — *General Entomological Laboratories.* — The equipment for work in entomology is perhaps unexcelled in this country. In the new fireproof entomological and zoölogical building, first used in the fall of 1910, are fine lecture rooms, laboratories and museums for use in the different courses. The senior laboratory will accommodate 70 students at one time; a desk, equipped with compound microscope and accessories, together with glassware, reagents, etc., and supplied with electric light and gas is provided for each student. Dissecting microscopes, microtomes and other apparatus are available for use. The graduate laboratory is similarly equipped, and it

will accommodate 20 students. The large and rapidly growing collections of insects are in a room adjoining both laboratories. In the library of the building is an excellent collection of the more important books and journals treating of entomology, and many more are accessible in the college library and in the private libraries of the professors, in all making available more than 25,000 volumes, many of which cannot be found elsewhere in the United States. A card catalogue giving references to the published articles on different insects contains more than 60,000 cards, and is the largest index of its kind in the United States, and probably in the world. In the basement is a pump room where may be studied the construction of the different types of spray pump and methods of repairing them; hose, couplings, nozzles and the other parts of spraying outfits are provided, not only for examination but for use. In another room chemical desks and apparatus provide opportunities for the determination of the impurities and adulterations of insecticides. As the insectary of the Massachusetts Agricultural Experiment Station is in the same building the facilities it offers are also available. A greenhouse, where plants infested with injurious insects are under observation and experimental treatment, is also open to students. Photographic rooms with cameras and other photographic apparatus are provided, and the large greenhouses, gardens, orchards and grounds of the college offer further opportunities for the study of injurious insects under natural conditions.

Entomology. — *Beekeeping.* — For this work the main office, museum and lecture rooms are in the entomological building. There is also an apiary covering approximately two acres which will consist of about fifty colonies of bees in various types of hives and maintained for the several practical and experimental purposes. The apiary also includes a collection of nectar-yielding plants representative of the native flora as well as of the more important nectar sources from other localities. Especial opportunity is therefore given for a study of this fundamental problem of forage. Upon the apiary site is an eight-room building (the first in the world erected exclusively for teaching beekeeping) modeled to meet both the requirements of teaching and of a practical apiary. This building contains a boiler room, capacious wintering cellar, wax extraction room, general carpenter and work shop, laboratory, office, honey extraction room and stock room. The beekeeping equipment also includes an unexcelled collection of apicultural implements, natural history specimens and other curiosities. Practically every device used in American apiculture is available, it being the aim of the department to procure new inventions and implements as fast as they appear for the purpose of study and comparison. Available to the students is a private library of apicultural literature consisting of upwards of 900 volumes and papers, possibly the most complete collection in the country. This entire equipment is acknowledged unique in model and in completeness for the United States and for the world.

Farm Administration. — The college farm of 250 acres is under the general supervision of the Department of Farm Administration, and furnishes demonstration material. It includes improved land, pasture land and a farm wood lot. The improved land illustrates the value of good culture and the best known methods for the maintenance of fertility. The farm is equipped with suitable buildings and good machinery for the work carried on, of which the production of certified milk is an important branch. Several good farms in the vicinity, illustrating types of both special and general agriculture, may be inspected and studied.

Floriculture. — The department of floriculture aims to give the student a thorough knowledge of all phases in greenhouse design and construction and greenhouse heating, and in the culture of florists' crops. It is intended to train men for commercial floriculture and for the management of conservatories on private estates and parks and in cemeteries. The course is outlined to combine theoretical, technical and practical work in the most comprehensive manner possible. Probably no agricultural college has a department of floriculture better equipped than this. There has been erected a durable, practical, commercial range, composed of palm, fern, orchid, violet, carnation, rose and students' houses. French Hall, with its large laboratories, class rooms and offices, furnishes excellent facilities for the purposes of instruction. Besides the new glass houses, there are older houses suitable for growing bedding plants and chrysanthemums, and frames for the growing of annual and herbaceous perennial plants, violets and pansies. Many excellent specimens of trees and shrubs are growing on the college grounds, furnishing valuable material for the study of plant materials.

Forestry. — The department of forestry has an unusually complete equipment of the various instruments used in forest mensuration, forest mapping and engineering, timber estimating, log scaling, board measuring, etc.; a large assortment of boards illustrative of the various commercial woods found in the lumber markets. The State Forest Nursery, comprising 6 acres of land and containing, approximately, 5,000,000 trees, transplants and seedlings is located on the college farm. Extensive forests containing every variety of tree common to New England are within walking distances of the college. The college campus affords an arboretum containing an exceptionally large number of trees not native to New England. The library contains complete sets of government bulletins, circulars, State reports and all the best books on forestry subjects.

Geology. — A large, well-lighted laboratory for geology, 27 by 50 feet, is in the basement of the new building for entomology, zoölogy and geology. This is equipped with cabinets, models, charts and a teaching collection of rocks. It has a seating capacity of 50 persons. Adjoining this is a smaller laboratory, 21 by 27 feet, for mineralogy, supplied with gas and cabinets for models, crystals and minerals. There is also a small laboratory for grinding thin sections, and a private laboratory, 6 by 19 feet, for analysis work. The geological museum is 27 by 48 feet. It has six large cases for exhibition purposes. The equipment for geology is being enlarged. At present, in addition to the general items mentioned above, it consists of a petrographic microscope, an illustrative series of thin sections, a small collection of invertebrate fossils, some casts of vertebrate fossils, a collection of the building stones of Massachusetts, and a duplicate set of the Edward Hitchcock survey collection of the rocks and minerals of Massachusetts.

Heating, Lighting and Power. — The college supplies its own light, heat and power, including electricity for the night lighting of the campus and its approaches. The machinery of the barn, the dairy and other buildings is operated by electricity generated at the power-house. The college has also a machine shop and well-equipped carpenter shop.

Landscape Gardening. — The work in landscape gardening is developed in a strong technical four-year course; the first two years are occupied with required studies, including botany, horticulture, surveying and mathematics, and the last two years are devoted to more specialized studies in landscape

gardening, arboriculture, floriculture, entomology, botany and mathematics. The environment is unusually favorable. The strictly technical work in landscape gardening is taught in light and comfortable drafting rooms, fully furnished with instruments and accessories for thorough work. There is a well-selected library, and the equipment of surveying and drafting instruments is unusually complete and practical.

Library. — The library — stack room, reading room and office — occupies the entire lower floor of the Chapel-library building. It contains nearly 45,000 volumes and a large number of pamphlets, hitherto inaccessible, but which are being put into good working order as fast as possible. Works of a scientific character predominate, but economics, literature and history are well represented and are receiving due attention. The reading room provides a variety of periodical literature, both technical and popular, encyclopedias and general reference books.

The library is now being reclassified and recatalogued, to make the splendid collection of material here gathered together readily accessible and of the greatest working value. Every effort is being made toward developing the library into a vital intellectual center of college life, of equal value to every student, teacher and teaching department. In consequence, only the most cordial relations are cherished, and the fewest and most imperative rules concerning the circulation of books and deportment are enforced.

Lectures are given to regular and short-course students to enable them to make the best use of the library. Emphasis is laid upon the proper use of the card catalogue, periodical indexes, bibliographies and guides; also, in general, assigned and class-room work, and essay and debate work.

The library hours are from 7.30 A.M. to 9.30 P.M. every week day, and from 9 A.M. to 2 P.M. on Sundays, in term time. Shorter hours prevail during vacations.

Market Gardening. — The purpose of the courses in market gardening is to acquaint the student with the theories and practice of market gardening so that he will be able to carry on the business intelligently. The equipment available for practical work consists of 10 acres of good gardening land; a large collection of horse and hand garden tools; hot-beds and cold-frames; and lettuce, cucumber and tomato houses. The students therefore have opportunity both to study and to practice the important branches of the business. Classes are taught in French Hall, a new building fitted with class rooms and laboratory particularly equipped for market gardening. A good library of works on vegetable gardening is available.

Mathematics and Civil Engineering. — *Surveying.* — The department has a considerable number of the usual surveying instruments, with the use of which the students are required to become familiar by doing field work. Among the larger instruments are 2 plain compasses, a railroad compass with telescope, a surveyor's transit, 3 engineer's transits with vertical arc and level, a Brandis solar transit, a solar compass, an omnimeter with verniers reading to 10 seconds, adapted to geodetic work, a Queen plane table, 3 wye levels, 2 dumpy levels, a builder's level, a sextant, a hand level, and a large assortment of leveling rods, flag poles, chains, tapes, etc. For drafting, a vernier protractor, a pantograph, a parallel rule, etc., are available. The department also has a Fairbanks cement testing outfit.

Military Science. — This department makes use of the campus for battalion drill, and has a special building in which there is a drill room 60

by 135 feet, an armory, an office for the commandant, a field-gun and gallery practice room and a large bathroom. The national government supplies Krag-Jorgensen rifles, with complete equipments and ammunition. The State supplies instruments for the college band. Students are held responsible for all articles of public property in their possession. The college owns an excellent target range for rifle practice, lying a short distance out of the village.

Physical Education. — The gymnasium and armory has a floor space of 5,000 square feet, and is 30 feet high, well lighted and ventilated. The main floor is used for basket ball, indoor baseball and hand ball. The gallery has been fitted up as a special exercise and gymnastic room, and is equipped with modern developing apparatus, including parallel bars, horses, bucks, chest weights, dumb bells, Indian clubs and striking bags. An outdoor board track enables students to secure track practice through the winter, and two ice hockey rinks give ample opportunity for hockey practice. Credit is given to all students taking part in outdoor activities. "Treks" are held twice a week, and whenever possible snowshoe and skiing hikes are also held. Steel lockers and bathrooms have been installed in North and South colleges, and the gymnasium has been fitted with a shower-room. The gymnasium classes are held the last two hours in the morning and the last two hours in the afternoon, but students may use the gymnasium at other times for exercise purposes by arrangement with the department. The regulation costume for class exercise consists of a white track suit and white rubber-sole shoes.

Physics. — Among the apparatus in use for instruction in general physics are a set of United States standard weights and measures, precision balances, a spherometer, vernier calipers, a projection lantern, etc.; in mechanics, a seconds clock, systems of pulleys and levers, and apparatus to illustrate the laws of falling bodies and motion on an inclined plane, and the phenomena connected with the mechanics of liquids and gases. The department is equipped with the usual apparatus for lecture illustration in heat, light and sound; in electricity, the equipment consists of apparatus for both lecture illustration and laboratory work, including a full set of Weston ammeters and volt meters, a Carhart-Clark standard cell, a Mascart quadrant electrometer, a Siemens electro-dynamometer, and reflecting galvanometers and Wheatstone bridges for ordinary determinations of currents and resistances.

Pomology. — The department of pomology has 45 acres of orchard, including apple, pear, peach, plum, cherry and quince trees. Of particular interest is the large collection of these fruits on the various dwarf stocks, showing many types of training. The recent revival of interest in dwarf fruits makes these dwarf orchards of especial value to students. There are also two commercial vineyards, and a smaller one in which are shown the principal types of trellis and the leading methods of training grapes. Several acres are used in growing the various kinds of small fruits, such as strawberries, raspberries, blackberries, currants and gooseberries. There are also nurseries, where all of these various types of fruits are grown, in which students may see them in all stages of development.

The department has a good equipment of orchard and nursery tools of all the principal types, the use of which enables students to learn the value of each type. For other orchard operations, such as spraying and pruning, the most approved makes of pumps, nozzles, pruning saws, knives, etc., are provided. For laboratory work in systematic pomology there is a collec-

tion of more than 100 wax models of apples, plums, pears and peaches, in natural colors, which are particularly valuable in identifying varieties of these fruits unknown to the student. The laboratory is also furnished with a large number of reference books on pomology; and fruit in a fresh condition is available in great variety, not only from the college orchards but from other parts of Massachusetts and from many other States. In 1912–13, for instance, apples for class use were received from Idaho, Missouri, Utah, Washington, Maine, Connecticut, Pennsylvania, Montana, Minnesota, Nebraska, Kentucky, Iowa, Wisconsin, Michigan, New York, Kansas, Colorado, Oregon, New Jersey and Vermont, besides collections of grapes from California and citrus fruit from Florida and Texas. From the college fruit plantations the following fruits were available: grapes, fifty varieties, representing three native American species and several hybrids; twenty varieties of peaches, twenty varieties of pears, twenty-five varieties of plums, eighty varieties of apples.

Poultry Husbandry. — The poultry plant consists of about 9 acres of land sloping gently to the west. The soil is a fine, rich, sandy loam, well drained. At present the buildings consist of an incubator cellar, 22 by 34 feet, with a capacity of 4,000 eggs, over which is a demonstration building; a pipe brood house (open-pipe system), 14 by 72 feet, which will accommodate 1,200 chickens; a long laying house, 14 by 180 feet, which accommodates 500 layers and furnishes facilities for student work in pen management; a laboratory, 14 by 80 feet, for killing, picking, dressing, crate fattening, cramming, etc.; a storage building, 28 by 42 feet, for experimental incubation, poultry carpentry, poultry mechanics and storage; an experimental breeding house, 18 by 60 feet; a combination laying, testing and breeding house, 18 by 72, for experimental purposes and a model laying house, 18 by 30, for 100 hens; the 6 old experiment station buildings, each 12 by 18 feet, to be used as breeding houses; 14 colony houses; 8 growing crops; a manure shed, 14 by 18 feet; and an oil house, 10 by 12 feet. Instruction in this department is given in the form of lectures, demonstrations and practical work. The practical work consists of poultry carpentry, caponizing, killing, picking, dressing, packing and selling poultry; pen management and fattening; running incubators and brooders, etc. At present the stock consists of 20 leading varieties of poultry. The aim of the department is to keep good specimens of all the most popular varieties of chicken, ducks and geese, so that a thorough course in poultry judging may be given, and that visitors may find the inspection of our stock an education in itself.

Public Speaking. — In connection with the work in public speaking, three regular contests are held during the year. The Burnham contest in declamation is open to freshmen and sophomores; the Flint contest in oratory and the annual debating contest are open (under restrictions) to all regular students. These contests offer a very practical and necessary experience to all students interested in improving themselves in the art of public speaking. Prizes are given for excellence in the contests. Intercollegiate contests are arranged by the Public Speaking Council. One credit is given, except to freshmen, for a year of work in the College Debating Club.

Veterinary Science. — The department of veterinary science occupies a modern laboratory and hospital stable, built in accordance with the latest principles of sanitation. Every precaution has been taken in the arrangement of details to prevent the spread of disease, and to provide for effective heating, lighting, ventilation and disinfection.

The main building contains a large working laboratory for student use, and several small private laboratories for special work. There is a lecture hall, a museum, a demonstration room, a photographing room and a work shop. The hospital stable contains a pharmacy, an operating hall, a post-mortem and dissecting room, a poultry section, a section for cats and dogs, and 6 sections, separated from each other, for horses, cattle, sheep and swine. The laboratory equipment consists of a dissectible Auzoux model of the horse and Auzoux models of the foot and the leg, showing the anatomy and the diseases of every part. The laboratories also have modern, high-power microscopes, microtomes, incubators and sterilizers, for work in every department of veterinary science including pathology, serology and parasitology. There are skeletons of the horse, the cow, the sheep, the dog and the pig, and a growing collection of anatomical and pathological specimens. The lecture room is provided with numerous maps, charts and diagrams.

Zoölogy. — The college offers increased facilities for the study of zoölogy. In the new building for entomology, zoölogy and geology are spacious laboratories for both undergraduate and graduate work. On the first floor is a large sophomore laboratory, 27 by 100 feet, with a present seating capacity of 100 persons. Adjoining this is a smaller room, 20 by 27 feet, for junior and senior courses. All laboratories are equipped with gas. The equipment consists of 80 compound microscopes and accessories, 70 dissecting microscopes, microtomes and accessories, paraffine baths, incubator, dissecting instruments, glassware and other necessary apparatus.

The large amphitheater lecture hall is used jointly by the departments of entomology and zoölogy-geology. It is equipped with charts and models. The zoölogical museum is drawn upon at all times for illustrative material. The zoölogical museum is 27 by 48 feet. The main room is on the first floor of the building. Above this, on a level with the second floor, is a large gallery. On the main floor are 8 large wall cases and 5 large floor cases for exhibition purposes. The gallery has 1 large wall case and 3 floor cases with space for 9 additional cases. The zoölogical collection consists of nearly 12,000 specimens. All the chief phyla are represented. Adjoining the museum is a preparator's room for the curator. The museum is open to the public from 1 to 5 p.m. on Saturdays, and on other week days from 3 to 6 p.m. The curator is Associate Professor Gordon.

PRIZES AND AWARDS, 1914.

Grinnell Prizes. — The Grinnell prizes, given by the Hon. William Claflin of Boston in honor of George B. Grinnell, Esq., of New York to those members of the senior class who pass the best, second best, and third best examinations, oral and written, in theoretical and practical agriculture, were awarded as follows: —

First prize, $25, awarded to Warren Sears Baker.

Second prize, $15, awarded to William Ashmun Davis.

Third prize, $10, awarded to Theodore Arthur Nicolet.

General Improvement. — The Western Alumni Association prize, given to that member of the sophomore class who during his first two years in college has shown the greatest improvement in scholarship, character and example was $25. This prize in 1914 was divided equally between Thomas Lincoln Harrocks and Raymond Alson Mooney.

Hills Botanical Prizes. — Awarded to the members of the sophomore class for the best and second best herbaria, as follows: —

First prize, $20, awarded to Kenneth Bradford Laird.

Second prize, $15, awarded to Thomas Carlton Upham.

Public Speaking. — The Burnham prizes, given to the students delivering the best and second best declamations, were awarded as follows: —

First prize, $15, awarded to Lincoln David Kelsey, 1917.

Second prize, $10, awarded to Suran Donald Sherinyan, 1916.

The Flint prizes were awarded to the students delivering the best and second best orations, as follows: —

First prize, $20, awarded to Frederick William Read, 1914.

Second prize, $15, awarded to Lincoln David Kelsey, 1917.

Military Honors. — The following-named cadet officers were reported to the Adjutant-General of the United States army and to the Adjutant-General of the Commonwealth of Massachusetts, as being efficient in military science and tactics and graduating therein with highest honors: —

Col. Stanley Barron Freeborn.

Maj. Harry Dunlap Brown.

Maj. Chester Eaton Wheeler.

Capt. Leone Ernest Smith.

Capt. Nathaniel Kennard Walker.

Capt. Richard Henry Powers.

Entomological Prize. — A special prize of $5, offered in 1914 to that member of the junior class presenting the best collections of insects, was awarded to Robert Theodore Frost, 1915.

SECRETARIES OF ALUMNI ASSOCIATIONS.

Associate Alumni of the Massachusetts Agricultural College.
Secretary: Dr. Charles A. Peters, 1897, Amherst, Mass.

Alumni Secretaries' Association of the Massachusetts Agricultural College.
Secretary: Ralph J. Watts, 1907, Amherst, Mass.

Alumni Club of Massachusetts.
Secretary: P. W. Pickard, 1911, 43 Chatham Street, Boston, Mass.

Connecticut Valley Association of the Massachusetts Agricultural College.
Secretary: Paul E. Alger, 1909, Warehouse Point, Conn.

Massachusetts Agricultural College Club of New York.
Secretary: Dr. John Ashburton Cutter, 1882, 266 West 77th Street, New York, N. Y.

Massachusetts Agricultural College Club of Washington, D. C.
Secretary: Dr. William A. Hooker, 1900, U. S. D. A., Office of Experiment Stations, Washington, D. C.

Western Alumni Association of the Massachusetts Agricultural College.
Secretary: Charles A. Tirrell, 1906, 4012 Perry Street, Chicago, Ill.

Massachusetts Agricultural College Pacific Coast Alumni Association.
Secretary: Thomas F. Hunt, 1905, Berkeley, Cal.

Massachusetts Agricultural College Club of Hawaii.
Secretary: Dr. E. A. Bach, 1904, Honolulu, T. H.

Class Secretaries.

Class of	Secretary.	Secretary's Address.
1871	E. E. Thompson, .	5 Jacques Avenue, Worcester, Mass.
1872	F. E. Kimball, . .	8 John Street, Worcester, Mass.
1873	C. Wellington, . .	Amherst, Mass.
1874	D. G. Hitchcock, .	Warren, Mass.
1875	M. Bunker, . .	28 Park Street, Newton, Mass.
1876	C. Fred Deuel, . .	Amherst, Mass.
1877	Atherton Clark, . .	231 Waverley Avenue, Newton, Mass.
1878	C. O. Lovell, . .	201 Darke Block, Regina, Saskatchewan, Can.
1879	R. W. Swan, . .	41 Pleasant Street, Worcester, Mass.
1880	Alvan L. Fowler, .	413 Post Office Building, Philadelphia, Pa.
1881	J. L. Hills, . .	59 North Prospect Street, Burlington, Vt.
1882	G. D. Howe, . .	25 Winter Street, Bangor, Me.
1883	J. B. Lindsey, . .	Amherst, Mass.
1884	E. A. Jones, . .	New Canaan, Conn.
1885	E. W. Allen, . .	1923 Biltmore Street, Washington, D. C.
1886	Dr. Winfield Ayres, .	616 Madison Avenue, New York City.
1887	F. H. Fowler, . .	Shirley, Mass.
1888	H. C. Bliss, . .	14 Mechanic Street, Attleborough, Mass.
1889	C. S. Crocker, . .	1003 South 25th Street, Philadelphia, Pa.
1890	David Barry, . .	398 Walnut Street, Newtonville, Mass.
1891	H. T. Shores, . .	177 Elm Street, Northampton, Mass.
1892	H. M. Thomson, .	Amherst, Mass.
1893	F. A. Smith, . .	Hathorne, Mass.
1894	S. F. Howard, . .	Northfield, Vt.
1895	E. A. White, . .	Ithaca, N. Y.
1896	A. S. Kinney, . .	South Hadley, Mass.
1897	C. A. Peters, . .	Amherst, Mass.
1898	W. S. Fisher, . .	Peace Street Grammar School, Providence, R. I.
1899	D. A. Beaman, . .	Rio Piedras, Porto Rico.
1900	E. K. Atkins, . .	15 Hubbard Avenue, Northampton, Mass.
1901	J. H. Chickering, .	Dover, Mass.
1902	H. L. Knight, . .	1420 Buchanan Street, Washington, D. C.
1903	G. D. Jones, . .	North Amherst, Mass.
1904	P. F. Staples, . .	Sherborn, Mass.
1905	A. D. Taylor, . .	1900 Euclid Avenue, Cleveland, O.
1906	Richard Wellington, .	St. Anthony Park, Minnesota.
1907	Clinton King, . .	31 Elm Street, Springfield, Mass.
1908	J. A. Hyslop, . .	860 North Mulberry Street, Hagerstown, Md.
1909	O. B. Briggs, . .	1015 Fidelity Building, Baltimore, Md.
1910	F. L. Thomas, . .	R. F. D. No. 2, Athol, Mass.
1911	L. M. Johnson, . .	Newtown, Conn.
1912	F. S. Madison, . .	East Greenwich, R. I.
1913	B. W. Ellis, . .	Amherst, Mass.
1914	L. Ernest Smith, .	Colchester, Conn.

Degrees Conferred and Roll of Students.

Degrees Conferred — 1914.

Doctor of Philosophy.

Merrill, Joseph Henry, Danvers, Mass., Dartmouth, B.Sc., 1909.
Smulyan, Marcus Thomas, Amherst, Mass., Massachusetts Agricultural College, B.Sc., 1909.
Thomas, Frank Lincoln, Athol, Mass., Massachusetts Agricultural College, B.Sc., 1910.

Master of Science.

Ackerman, Arthur John, Worcester, Mass., Massachusetts Agricultural College, B.Sc., 1912.
Fowler, George Scott, Wayland, Mass., Massachusetts Agricultural College, B.Sc., 1912.
Hutson, John Coghlan, Bridgetown, Barbados, Oxford University, B.A., 1909.
Martin, James Francis, Amherst, Mass., Massachusetts Agricultural College, B.Sc., 1912.
Noyes, Harry Alfred, Lafayette, Ind., Massachusetts Agricultural College, B.Sc., 1912.
Parker, Ralph Robinson, Penikese, Mass., Massachusetts Agricultural College, B.Sc., 1912.
Ruprecht, Rudolf William, Brooklyn, N. Y., Rhode Island Agricultural College, B.Sc., 1911.
Tower, Daniel Gordon, Roxbury, Mass., Massachusetts Agricultural College, B.Sc., 1912.

Bachelor of Science (B.Sc.).

Abbott, Leslie Elmer,	Sandwich.
Allen, Carl Murdough,	Holyoke.
Baker, Warren Sears,	Wollaston.
Black, Harold Cotting,	Falmouth.
Bokelund, Chester Story,	Worcester.
Bradley, John Watling,	Groton.
Bragg, Ralph Stanley,	Milford.
Brewer, Harold William,	Mount Vernon, N. Y.
Brooks, Arthur Winslow,	Smiths.
Brown, Harry Dunlap,	Lowell.
Calvert, Melville Bradford,	New London, Conn.
Campbell, Malcolm David,	Still River.
Christie, Edward Wheeler,	North Adams.
Churchill, George Clarence,	Worcester.
Clark, Ernest Samuel, Jr.,	Tolland.
Clay, Harold Johnson,	Cambridge.
Clegg, Frank Jackson,	Fall River.
Coleman, David Augustus,	South Framingham.
Davies, Lloyd Garrison,	Peabody.
Davis, Ralph Edward,	Southbury, Conn.
Davis, William Ashmun,	Northfield.
Dearing, Newton Howard,	Brookline.
Dexter, Evans King,	Mattapoisett.
Dunbar, Erving Walker,	North Weymouth.
Edgerton, Almon Morley,	Mittineague.
Edwards, Edward Clinton,	North Beverly.
Eldridge, Harold Lockwood,	Wareham.
Foster, Stuart Brooks,	West Somerville.
Freeborn, Stanley Barron,	Ware.
Freedman, Samuel Leavitt,	Roxbury.
Frye, Carl Raymond,	South Hadley Falls.
Fuller, George,	Deerfield.
Hadfield, Harold Frederick,	North Adams.
Handy, Ralph Ellis,	Cataumet.

Harris, Rodney Wells,	Wethersfield, Conn.
Hazen, Edward Leonard,	Springfield.
Hebard, Emory Blodgett,	Holland.
Heffron, Frederick,	Sherborn.
Hill, Charles Chase,	Melrose Highlands.
Hogg, Lawrence Jagger,	Lawrence.
Howard, Lewis Phillips,	North Easton.
Hutchinson, John Gouverneur,	Arlington.
Ingham, Earl Morris,	Granby.
Jacobs, Loring Humphrey,	Wellesley.
Jones, Dettmar Wentworth,	Melrose.
Leete, Richard Fowler,	Mount Kisco, N. Y.
Levine, Henry Walter,	Roxbury.
Lincoln, Murray Danforth,	Raynham.
Lucas, Hoyt Dennis,	Springfield.
Lundgren, Arthur Robert,	Orange.
Major, Joseph,	East Rutherford, N. J.
Marsh, Frank Eugene,	Jefferson.
Merkle, Frederick Grover,	Amherst.
Morrison, Harold Ivory,	Melrose.
Morse, Harold John,	Townsend.
Needham, Lester Ward,	Springfield.
Nicolet, Theodore Arthur,	Fall River.
Nicolet, Tell William,	Fall River.
Nissen, Harry,	Boston.
Norton, Leslie Howard,	Newport, R. I.
Nute, Raymond Edson,	Fall River.
O'Brien, Daniel William,	Wayland.
Oertel, John Thomas,	South Hadley Falls.
Parker, Ervine Franklin,	Poquonock, Conn.
Payne, Roland Alfred,	Wakefield.
Pellett, John Doubleday,	Worcester.
Peters, Chester Harry,	Clinton.
Petersen, Peveril Oscar,	Concord.
Porter, Bennett Allen,	Amherst.
Powers, Richard Henry,	Malden.
Read, Frederick William,	Boston.
Reid, George Alexander,	Worcester.
Rosebrooks, Walter Edwin,	West Sutton.
Russell, Alden Hesseltine,	Watertown.
Sahr, Gabriel William Arthur,	Boston.
Sherman, Joel Powers,	Hyannis.
Small, Francis Willard,	North Truro.
Smith, Leon Edgar,	Boston.
Smith, Leone Ernest,	Leominster.
Stevens, Arthur Eben,	Lawrence.
Strange, Sarah Josephine,	Marshfield.
Tarbell, Munroe Gifford,	Brimfield.
Taylor, Arthur Wright,	Feeding Hills.
Taylor, Leland Hart,	Peabody.
Thurston, Arthur Searle,	Everett.
Tower, Alfred Leigh,	Sheffield.
Tupper, Arthur Sommerville,	Roxbury.
Upton, Ernest Franklin,	Salem.
Walker, Nathaniel Kennard,	Malden.
Walker, Raymond Philip,	Taunton.
Warner, Raymond Winslow,	Sunderland.
Webster, Louis Armstrong,	Blackstone.
Weigel, Arthur George,	Lawrence.
Wheeler, Chester Eaton,	Lowell.
Whidden, Burton Clark,	Lowell.
Whippen, Charles Warren,	Lynn.
Wing, John Govan,	Somerville.
Wood, Henry Joseph,	Mendon.

Roll of Students.

Graduate Students — Candidates for a Degree.

Anderson, David Wadsworth, ... Manchester, N. H.
B.Sc., New Hampshire State College.
Avery, Roy Crowdy, ... New York, N. Y.
B.Sc., Connecticut Agricultural College.
Baird, Charles Glenn, ... Powell, Wyoming.
A.B., University of Kansas; A.M., University of Wyoming.
Baker, Herbert J., ... Selbyville, Del.
B.Sc., Massachusetts Agricultural College.
Bales, Harold C., ... North Amherst.
A.B., Dartmouth.
Beals, Carlos Loring, ... Sunderland.
B.Sc., Massachusetts Agricultural College.
Bogue, Robert H., ... North Amherst.
B.Sc., Tufts.
Bourne, Arthur Israel, ... Kensington, N. H.
A.B., Dartmouth.
Bronson, Wesley Hotchkiss, ... Marlborough.
B.Sc., New York State College of Agriculture.
Brown, Henry L., ... Ayer.
B.Sc., University of Maine.
Chapman, George H., ... Amherst.
B.S. and M.S., Massachusetts Agricultural College.
Copson, Godfrey Vernon, ... Grand Rapids, Mich.
B.Sc. in agriculture, Oregon Agricultural College.
Davies, Ernest Langford, ... Guelph, Can.
B.Sc., Ontario Agricultural College.
Foster, Leo T., ... Leominster.
A.B., Holy Cross College.
Frost, Walter S., ... Roxbury.
B.S. in chemistry, Tufts College.
Gurley, Franklin Cornell, ... South Willington, Conn.
B.Sc., Worcester Polytechnic Institute.
Hasey, Willard Harrison, ... Brockton.
B.Sc., Massachusetts Agricultural College.
Hillary, Walter Hoxie, ... Philadelphia, Pa.
B.Sc., Pennsylvania State College.
Holland, Edward Bertram, ... Amherst.
M.Sc., Massachusetts Agricultural College.
Hood, Egerton Gibson, ... Hagermon, Ontario, Can.
B.Sc., Ontario Agricultural College.
Hutson, John Coghlan, ... Bridgetown, Barbados.
A.B., Trinity College, Oxford, Eng.; M.Sc., Massachusetts Agricultural College.
Itano, Arao, ... Okayamaken, Japan.
B.Sc., Michigan Agricultural College.
Lund, Russell Fort, ... West Pelham.
B.A., St. Lawrence University.

Martin, James Francis, ... Amherst.
M.Sc., Massachusetts Agricultural College.
McDougall, Allister F., ... Westford.
B.Sc., Massachusetts Agricultural College.
McLaughlin, Frederick Adams, ... Lee.
B.Sc., Massachusetts Agricultural College.
Merkle, Frederick Grover, ... Amherst.
B.Sc., Massachusetts Agricultural College.
Miller, Stuart Parmelee, ... East Hampton, Conn.
B.Sc., Worcester Polytechnic Institute.
Mutkekar, Satwaji Gundoji, ... Belgaum, India.
B.Agr., Poona Agricultural College, India.
Norton, John Buck, ... Hartford, N. Y.
B.Sc., University of Vermont.
Oberhelman, Carl F., ... Norwood, O.
B.Sc. in agriculture, Ohio State University.
Paige, Beryl Holmes, ... Amherst.
A.B., Mount Holyoke College.
Parker, Ralph Robinson, ... Penikese.
B.Sc. and M.Sc., Massachusetts Agricultural College.
Porter, Bennet Allen, ... Amherst.
B.Sc., Massachusetts Agricultural College.
Regan, William Swift, ... Northampton.
B.Sc., Massachusetts Agricultural College.
Robinson, Harold A., ... Elmwood, N. H.
B.Sc., New Hampshire State College.
Root, George Albert, ... Danbury, Conn.
B.Sc., Connecticut Agricultural College.
Sanctuary, William Crocker, ... Morrisville, N. Y.
B.Sc., Massachusetts Agricultural College.
Serex, Paul, Jr., ... Bloomfield, N. J.
B.Sc., Massachusetts Agricultural College.
Smith, Raymond Goodale, ... Lynn.
B.Sc., Massachusetts Agricultural College.
Strand, Carl J., ... Amherst.
A.B., Augustana College; M.A., University of Illinois.
Taylor, Leland H., ... Peabody.
B.Sc., Massachusetts Agricultural College.
Thurston, Arthur S., ... Everett.
B.Sc., Massachusetts Agricultural College.
Wang, Iu Tso, ... Canton, China.
B.Sc., Cornell University.
White, Edward Albert, ... Ithaca, N. Y.
B.Sc., Massachusetts Agricultural College.
Whittier, Warren Faxon, ... Amherst.
A.B., Harvard University.

Graduate Students — not Candidates for a Degree.

Cowell, Harold Cobb, ... Ashburnham.
A.B., Williams College.
Farrar, Marion A., ... South Framingham.
A.B., Boston University.
Hooker, Elizabeth Robbins, ... Dorchester.
A.B., Radcliffe College.
Martindale, Henrietta, ... La Crosse, Wis.
A.B., Smith College.
Middleton, Frederick Heard, ... Brookline.
A.B., Harvard University.
White, Gertrude Moody, ... Hartford, Conn.
A.B., Vassar.

Senior Class.

Alden, Charles Harold,	Amherst,	17 Phillips Street.
Allen, Francis Ellwood,	Melrose,	3 North College.
Archibald, Herbert Hildreth,	Waltham,	14 South College.
Banister, Seth Warrener,	Westford,	16 North College.
Bartlett, Edward Russell,	Newburyport,	3 Nutting Avenue.
Bartley, Hastings Newcomb,	Sandwich,	9 South College.
Bemis, Willard Gilbert,	North Brookfield,	Commons Club.
Bennett, John Ingram, [1]	Boston,	66 Pleasant Street.
Bishop, Chester Allen,	Peterboro, N. H.,	7 North College.
Brooks, Gardner Milton,	Boston,	Box 31, M. A. C.
Buell, Frank Weed,	New Haven, Conn.,	5 South College.
Burt, Helen Frances,	West Somerville,	Draper Hall.
Buttrick, John Willard,	Melrose,	18 Nutting Avenue.
Cale, Gladstone Hume,	Springfield,	90 Pleasant Street.
Cande, Donald Hopkins,	Pittsfield,	87 Pleasant Street.
Chase, Alexander Baxter, Jr.,	West Barnstable,	Clark Hall.
Clark, Ellis Fred,	Granby, Conn.,	3 South College.
Cleveland, Waldo Atwood, [1]	Baldwinsville,	Veterinary Laboratory.
Clough, Maurice Joseph,	Boston,	7 South College.
Dalrymple, Andrew Campbell,	Revere,	2 North College.
Damon, Leon Blanchard,	Melrose,	3 North College.
Day, George Allen,	Warren,	1 North College.
Dole, Sumner Alvord,	Shelburne,	11 North College.
Doran, William Leonard,	North Dartmouth,	French Hall.
Draper, Earle Sumner,	Milford,	15 South College.
Farrar, Stuart Kittridge, [1]	Springfield,	96 Pleasant Street.
Fitzgerald, Daniel James,	Worcester,	2 North College.
Flebut, Alpha John,	Amherst,	27 McClellan Street.
Frost, Robert Theodore,	New York, N. Y.,	85 Pleasant Street.
Fuller, Richard, [1]	Salem,	44 Triangle Street.
Goodwin, Malcolm Noyes,	Newburyport,	96 Pleasant Street.
Grant, Harold Davidson,	Methuen,	15 North College.
Griggs, Raymond Bradford, [1]	Chicopee Falls,	11 South College.
Hall, George Morris, [1]	Brookline,	85 Pleasant Street.
Hall, Roderick Chesley, [1]	Worcester,	Beta Kappa Phi.
Harper, James Edward, [1]	New Haven, Conn.,	2 North College.
Harvey, Russell Wilton,	Lanesville,	44 Pleasant Street.
Haskell, Willis Henry, Jr.,	Brooklyn, N. Y.,	116 Pleasant Street.
Hatfield, William Hollis,	Wellesley,	87 Pleasant Street.
Hildreth, Paul Hughes,	Newtonville,	13 South College.
Hotis, Ralph P.,	Evans Mills, N. Y.,	21 Amity Street.
Hyde, George Frederick,	Hartford, Conn.,	Beta Kappa Phi.
Hyde, Harold Gilmore,	Winchendon,	12 North College.
Johnson, Arthur,	Bridgeport, Conn.,	7 South College.
Kelleher, Jerome Joseph,	Turners Falls,	5 East Pleasant Street.
Kennedy, Worthington Chester,	Hardwick,	6 North College.
Lane, Merton Chesleigh,	South Duxbury,	Mathematics Building.
Le Duc, Ashley Cudworth,	Chesterfield,	Commons Club.
Lewis, Daniel James,	Hanson,	96 Pleasant Street.
Lewis, John Kirby,	New Haven, Conn.,	1 North College.
Lincoln, Irving Boin,	Glens Falls, N. Y.,	2 South College.
Lovejoy, John Sumner, [1]	Newburyport,	9 North College.
MacNeil, Ralph Langdel, [1]	Chelsea,	Mathematics Building.
Macy, Philip Arthur,	Oak Bluffs,	10 North College.
Marsh, Franklin Winter,	Amherst,	18 Nutting Avenue.
Marsh, Herbert Vener,	Deerfield,	4 South College.
Massé, Sidney Merton,	Dorchester,	3 South College.
McKechnie, Ray Farrar,	Natick,	11 Pleasant Street.
McLain, Ralph Emerson,	Melrose,	20 South College.

[1] Work incomplete.

Melican George Deady,	Worcester,	8 South College.
Moberg, Eldon Samuel,	Campello,	83 Pleasant Street.
Montague, Enos James,	Northampton,	3 South College.
Moore, Roger Henry,	Beverly,	15 North College.
Navas, Miguel,[1]	Barranquilla, Col., South America.	6 Phillips Street.
Parker, Edwin Kenney,	Northampton,	8 Allen Street.
Parmenter, Ernest Brigham,	Franklin,	13 North College.
Patterson, Robert Earley,	Dorchester,	14 North College.
Pease, Willard Noah Morris,[1]	Amherst,	Brooks Farm.
Pendleton, Harlow Libby,[1]	Dorchester,	Flint Laboratory.
Perry, Gerald Eugene,	Amherst,	Prospect House.
Pike, Joseph Stevens, Jr.,[1]	Somerville,	8 North College.
Potter, George Raymond,	Ludlow,	44 Pleasant Street.
Price, James Albert,	New York, N. Y.,	14 South College.
Rhoades, Paul Whitney,[1]	Malden,	4 North College.
Rogers, Harold Merriman,	Southington, Conn.,	87 Pleasant Street.
Sauchelli, Vincent,	Waterbury, Conn.,	6 Maple Street.
Sears, William Richard,	Woburn,	10 South College.
Severance, Verne Lincoln,	South Hanson,	Mathematics Building.
Sherman, Milton Francis,	South Lincoln,	10 Allen Street.
Simon, Isaac Barney,	Revere,	38 Cottage Street.
Slein, Owen Francis,	New Braintree,	12 North College.
Smith, Hyde,	Worcester,	1 South College.
Spicer, Eber Grant,	New York, N. Y.,	44 Triangle Street.
Spofford, Chester Porter,[1]	South Groveland,	6 North College.
Stanford, Ernest Elwood,	Amherst,	4 Walnut Street.
Taft, Richard Craig,[1]	Oxford,	88 Pleasant Street.
Tarr, Lester Winslow,	Rockport,	90 Pleasant Street.
Tower, Ralph Ernest,	Becket,	College Commons.
Tower, William Reginald,	Sheffield,	Mount Pleasant.
Towne, Edwin Chester,	Waltham,	7 North College.
Upton, Raymond Melville,	Peabody,	Durfee Plant House.
Vener, Benjamin,	Brockton,	1 South College.
Vinal, Stuart Cunningham,	Boston,	10 North College.
Wellington, Benjamin,	Waltham,	15 Phillips Street.
White, Henry Harrison,	West Peabody,	4 South College.
White, Homer Beethoven,[1]	Melrose Highlands,	15 Phillips Street.
Whitmore, Philip Ferry,	Sunderland,	88 Pleasant Street.
Whorf, Paul Francis,	Caribou, Me.,	4 South College.
Wilkins, Alfred Emerson,[1]	Wakefield,	2 South College.
Willey, Harold Cleland Clancey,	Orange,	M. A. C. Plant House.
Williams, Donald,[1]	Catasauqua, Pa.,	85 Pleasant Street.
Wright, Elvin Stanley,	Worcester,	88 Pleasant Street.
Zehrung, Samuel Danford,[1]	Roseville, O.,	81 Pleasant Street.

Junior Class.

Aiken, Harold,[1]	Millis,	82 Pleasant Street.
Anderson, Frank Albert,[1]	Somerville,	12 South College.
Andrews, Francis Marshall, Jr.,[1]	Manchester,	53 Lincoln Avenue.
Barnes, Dwight Fletcher,	Marshfield,	Entomology Building.
Barnes, Fred Leslie Walker,[1]	Plymouth,	90 Pleasant Street.
Bishop, Herbert Walker,[1]	Doylestown, Pa.,	85 Pleasant Street.
Blanpied, Nelson Uhler,	Framingham,	M. A. C. Farm House.
Boyer, Edward Everett Hale,[1]	Lynn,	30 North Prospect Street.
Brazil, William Henry,[1]	Leominster,	116 Pleasant Street.
Bronson, Harold Julian,[1]	Buckland,	Fitts' House.
Caldwell, Harold Nute,[1]	Lowell,	M. A. C. Farm House.
Cardarelli, Emilio Joseph,	Boston,	West Experiment Station.
Chase, Esther Helen,[1]	Holden,	Draper Hall.
Chisholm, Raymond Lincoln,	Melrose Highlands,	66 Pleasant Street.

[1] Work incomplete.

Clapp, Raymond Luckey,	Northfield,	Care of E. F. Gaskill.
Clark, Saxon Dickinson,[1]	Springfield,	Commons Club.
Coe, Alfred Lynn,	Fayetteville, N. Y.,	90 Pleasant Street.
Coleman, Albert Sumner,[1]	Mendon,	6 Maple Avenue.
Coley, William Stanton,[1]	Wilton, Conn.,	87 Pleasant Street.
Courchene, Alcide Telesphor,[1]	North Adams,	Kappa Gamma Phi.
Curran, Harry Ambrose,	Marlborough,	Kappa Gamma Phi.
Cushing, Raymond Alonzo,[1]	West Somerville,	13 Phillips Street.
Danforth, George Newlin,[1]	Foxcroft, Me.,	96 Pleasant Street.
Darling, Homer Chester,	Mendon,	5 South College.
Davis, Frank Leslie,[1]	Hopedale,	North Pleasant Street.
Dickinson, William Cowls,	North Amherst,	North Amherst.
Dodge, Walter Eugene,	Geneva, O.,	13 Phillips Street.
Eldredge, Raymond Chase,	North Abington,	Mount Pleasant.
Estes, Ralph Cary,[1]	South Framingham,	Care of Professor Morton.
Fernald, Charles Henry, 2d,	Amherst,	44 Amity Street.
Fielding, Lester Edward,	Malden,	96 Pleasant Street.
Fisher, George Basil,[1]	Millbury,	88 Pleasant Street.
Gaventa, Harry Reymer,	Swedesboro, N. J.,	Commons Club.
Gilmore, Benjamin Anthony,[1]	Acushnet,	90 Pleasant Street.
Gioiosa, Alfred Anthony,	Dorchester,	16 South College.
Glover, Theodore Whitford,[1]	South Duxbury,	R. F. D. No. 3, Box 79.
Goodwin, Clinton Foster,[1]	Haverhill,	82 Pleasant Street.
Googins, Burton,[1]	Amherst,	35 East Pleasant Street.
Gould, Charles Holt,	Worcester,	88 Pleasant Street.
Gunn, Carlton Merrick,	Sunderland,	90 Pleasant Street.
Hager, Clayton Marden,	Winter Hill,	M. A. C. Store.
Hall, Stanley William,	Saxonville,	96 Pleasant Street.
Harris, William Lombard, Jr.,[1]	Deerfield,	90 Pleasant Street.
Harrocks, Thomas Lincoln,	Westminster,	87 Pleasant Street.
Hart, Reginald,[1]	Montague City,	10 North College.
Haskell, Frank Eugene,	Northborough,	82 Pleasant Street.
Hathaway, Charles Edward, Jr.,[1]	Somerset,	87 Pleasant Street.
Hemenway, Justin Stanley,[1]	Williamsburg,	37 East Pleasant Street.
Hendry, Arthur Ekman,[1]	Mattapan,	18 Nutting Avenue.
Hicks, Albert James,[1]	Amherst,	East Experiment Station.
Holden, Mae Faustina,	Royalston,	Care of Professor Hasbrouck.
Hunt, Reginald Stuart,[1]	Newtonville,	Commons Club.
Huntington, Charles Albert, Jr.,	Poquonock, Conn.,	96 Pleasant Street.
Jerome, Frederick William,[1]	Stockbridge,	Prospect Street.
Jones, Linus Hale,[1]	Milford,	Care of Mr. Green, Mount Pleasant.
Jordan, Perley Black,[1]	Topsfield,	13 South College.
Kelly, Harold Russell,[1]	Haverhill,	Pease Avenue.
Kilbon, Ralph Gillette,[1]	Springfield,	Brooks Farm.
King, Edward Lee,[1]	Dorchester,	6 South College.
Knapton, Guy Lord,	Lawrence,	Pease Avenue.
Laird, Kenneth Bradford,	Whitman,	79 Pleasant Street.
Lieber, Conrad Hugo,	Jamaica Plain,	Kappa Gamma Phi.
Lindquist, Albert Evert,	Jamaica Plain,	Physics Building.
Little, Harold Greenleaf,[1]	Newburyport,	96 Pleasant Street.
Locke, Wilber Trow,	Lawrence,	85 Pleasant Street.
Lyford, Waldo Preston,[1]	Natick,	13 South Prospect Street.
Mahan, Harold Butterworth,[1]	Boston,	Kappa Gamma Phi.
Mahony, William John,[1]	Sterling,	6 South College.
Mattoon, Harold Gleason,	Pittsfield,	87 Pleasant Street.
Mooney, Raymond Alson,[1]	Plattsburgh, N. Y.,	85 Pleasant Street.
Moses, Charles Wicker,	Ticonderoga, N. Y.,	9 North College.
Mostrom, Harold Augustus,	North Middleborough,	10 Nutting Avenue.
Murphy, John William,	Beverly,	66 Pleasant Street.
Nash, Clayton Wells,	South Weymouth,	Commons Club.
Nicholson, James Thomas,[1]	Leominster,	116 Pleasant Street.

[1] Work incomplete.

O'Brion, Edwin Fulton,[1]	Somerville,	Commons Club.
Palmer, George Bradford,	Brookline,	96 Pleasant Street.
Perry, Edgar Adams,[1]	Attleborough,	21 Amity Street.
Plaisted, Philip Asbury,	Arlington,	15 Beston Street.
Potter, David,	Concord,	9 South College.
Prouty, Stanley Marshall,	North Brookfield,	96 Pleasant Street.
Ray, George Burrill,[1]	Hingham,	Kappa Gamma Phi.
Rich, Gilbert Warren,[1]	Hingham,	Care of Professor Morton.
Richards, Everett Stackpole,	Northampton,	96 Pleasant Street.
Ricker, Dean Albert,	Worcester,	7 North College.
Rogers, Tyler Stewart,	Saxonville,	12 South College.
Rowe, Louis Victor,[1]	Melrose,	90 Pleasant Street.
Russell, Ernest Samuel,	South Hadley,	96 Pleasant Street.
Ryan, William Edward, Jr.,[1]	Stoughton,	5 Sunset Avenue.
Sander, Benjamin Charles Louis,[1]	Cambridge,	College Store.
Sanderson, Everett Shovelton,	Centreville, R. I.,	10 Nutting Avenue.
Scheufele, Frank Joseph,	South Natick,	15 Beston Street.
Schlotterbeck, Lewis,[1]	Roxbury Station, Conn.,	85 Pleasant Street.
Selkregg, Edwin Reimund,[1]	North East, Pa.,	81 Pleasant Street.
Sherinyan, Donald,[1]	Worcester,	35 North Prospect Street.
Simmons, Perez,	Pittsfield,	82 Pleasant Street.
Stearns, Frederick Campbell,[1]	Waltham,	30 Prospect Street.
Strauss, Abraham,	Roxbury,	Clark Hall.
Swan, Durelle,	Dorchester,	18 Nutting Avenue.
Taber, Ralph Fred,	Cooperstown, N. Y.,	Mount Pleasant.
Topham, Alfred,	Lawrence,	116 Pleasant Street.
Upham, Thomas Carlton,[1]	Fitchburg,	53 Lincoln Avenue.
Verbeck, Howard Graves,	Malden,	12 South College.
Walkden, Herbert Halden,	Westford,	Kappa Gamma Phi.
Walker, Henry Marshall,	Brookline,	Kappa Gamma Phi.
Wentworth, Everett Lawrence,	East Dover, Vt.,	30 North Prospect Street.
Wetherbee, Raymond Swift,	Waltham,	90 Pleasant Street.
White, Samuel Alexander,[1]	Boston,	38 College Street.
Whitney, Harold Tichenor,[1]	Mount Vernon, N. Y.,	8 North College.
Whitney, Leon Fradley,	Brooklyn, N. Y.,	96 Pleasant Street.
Wies, Calmy,	Malden,	38 Cottage Street.
Wildon, Garrick Earl,	Melrose Highlands,	66 Pleasant Street.
Woolley, Harold Curtis,	Malden,	96 Pleasant Street.

Sophomore Class.

Adams, Henry Leo[1]	Newburyport,	3 Nutting Avenue.
Alcott, William Jefferson,[1]	Everett,	90 Pleasant Street.
Aloe, Myron,[1]	Philadelphia, Pa.,	73 Pleasant Street.
Babbitt, George King,[1]	Boston,	Care of Professor Morton.
Babcock, Philip Rodney,[1]	Lynn,	96 Pleasant Street.
Barnes, Herbert Wesley,	Whitinsville,	Commons Club.
Behrend, Oswald,	Natick,	Commons Club.
Bell, Alfred Whitney, Jr.,[1]	West Newton,	53 Lincoln Avenue.
Bent, Winthrop Herbert,[1]	Watertown,	87 Pleasant Street.
Birchard, John Dickson,	Springfield,	14 Nutting Avenue.
Bisbee, Philip Emerson,[1]	Waitsfield, Vt.,	85 Pleasant Street.
Boaz, William Henry,[1]	Covesville, Va.,	6 Nutting Avenue.
Boles, Robert Stewart,	Dorchester,	4 Chestnut Street.
Bonn, Wesley Copeland,	Grafton,	5 Nutting Avenue.
Booth, Alfred,[1]	Middletown, N. Y.,	Care of Professor Morton.
Boyce, Harold Prescott,[1]	Haverhill,	7 Nutting Avenue.
Bradley, William George,[1]	Groton,	88 Pleasant Street.
Buchanan, Walter Gray,[1]	Chicopee,	97 Pleasant Street.
Buck, Rollin Hugh,[1]	Worcester,	90 Pleasant Street.
Buckman, Lewis Taylor,	Wilkes-Barre, Pa.,	88 Pleasant Street.
Burleigh, Arthur Leslie,[1]	Lynn,	85 Pleasant Street.

[1] Work incomplete.

Burnham, Chester Arthur,	Westford,	Fitts House.
Buttrick, David Herbert,	Arlington,	120 Pleasant Street.
Calderwood, Herbert Hale,[1]	Rockport, Me.,	Nutting Avenue, Care of Mr. Plumb.
Carruth, Glenn Howard,[1]	Orange,	36 North Prospect Street.
Chamberlain, Sumner Fiske,	Holden,	Commons Club.
Chamberlin, Frank Shirley,[1]	South Framingham,	3 McClellan Street.
Chamberlin, Raymond,[1]	New York, N. Y.,	85 Pleasant Street.
Cotton, Elwyn Page,[1]	Woburn,	East Experiment Station.
Cross, Walter Irving,	Hingham,	53 Lincoln Avenue.
Davis, Monsell Henry,	Orange, N. J.,	Care of S. J. Wright.
Day, James Harold,	Hatfield,	16 South College.
Dempsey, Paul Wheeler,	Dorchester,	82 Pleasant Street.
Dickey, Harold Gammell,	Dorchester,	Poultry Plant.
Dinsmore, Donald Sanderson,	Springfield,	88 Pleasant Street.
Dizer, John Thomas,	East Weymouth,	West Experiment Station.
Dudley, Lofton Leland,	Belchertown,	Belchertown.
Duffill, Edward Stanley,[1]	Melrose Highlands,	17 Fearing Street.
Dunham, Henry Gurney,	West Bridgewater,	79 Pleasant Street.
Dunn, Arthur Paul,	Malden,	4 Chestnut Street
Edwards, Francis Gill,[1]	Beverly,	83 Pleasant Street.
Elliot, Ralph William,	Chartley,	Flint Laboratory.
Everbeck, George Charles,	Winthrop,	Care of Mr. Green, Mount Pleasant.
Fearing, Ralph Watson,	Dorchester,	7 Nutting Avenue.
Ferris, Adaline Lawson,	Ridgefield Park, N. J.,	Draper Hall.
Flagg, Wayne McCrillis,[1]	Mittineague,	90 Pleasant Street.
Flint, Oliver Simeon,	Lowell,	120 Pleasant Street.
Goldstein, Maurice,	West Lynn,	58 Pleasant Street.
Graham, Leland Jenkins,	Amherst,	Lincoln Avenue.
Grayson, Emory Ellsworth,	Milford,	Care of Professor Morton.
Groff, Howard Clarkson,[1]	Amherst,	South Pleasant Street.
Gurshin, Carl Alfred,	Lynn,	35 North Prospect Street.
Hagelstein, Charles Henry,	Dorchester,	Kappa Gamma Phi.
Hallett, Charles Hiram,[1]	Mansfield,	120 Pleasant Street.
Harlow, Frank Edward,	Malden,	77 Pleasant Street.
Harlow, Paul Goodhue,	Malden,	77 Pleasant Street.
Heffron, Paul John,[1]	Sherborn,	North Pleasant Street.
Henderson, Elliott,	Hingham,	9 South College.
Higginbotham, Harry,	Taunton,	88 Pleasant Street.
Higgins, Gardner William,	Norfolk,	85 Pleasant Street.
Hill, Edmund Baldwin,[1]	Rutherford, N. J.,	85 Pleasant Street.
Holden, Richard Lynde,	Haverhill,	82 Pleasant Street.
Holder, Ralph Clifton,	Millis,	17 Kellogg Avenue.
Holt, Francis Stetham,[1]	Cambridge,	77 Pleasant Street.
Hooper, Albert Averill,[1]	Lynn,	96 Pleasant Street.
Hubbell, Franklin Homer,	Westport, Conn.,	M. A. C. Farm House.
Illman, Margaret Keble,	Amherst,	Amherst, R. F. D. No. 2.
Irving, William Raymond,[1]	Taunton,	88 Pleasant Street.
Jackson, Richmond Merrill,	Georgetown,	36 North Prospect Street.
Keegan, Thomas Michael,[1]	Worcester,	88 Pleasant Street.
Kelsey, Edmund Dean,[1]	Amherst,	Pelham Road.
Kelsey, Lincoln David,	West Hartford, Conn.,	90 Pleasant Street.
Kinsman, Alfred Oberlin, Jr.,[1]	Merrimac,	17 Kellogg Avenue.
Larson, Frederick Christian,[1]	Everett,	Kappa Gamma Phi.
Latham, Paul Walker,	Norwich Town, Conn.,	96 Pleasant Street.
Lawrence, Milford Robinson,	Falmouth,	83 Pleasant Street.
Light, Brooks,[1]	Milton,	73 Pleasant Street.
Livermore, William Tingley,	Lawrence,	83 Pleasant Street.
Loring, Albert Briggs,	Nantasket Beach,	53 Lincoln Avenue.
Lydiard, Harry Crowther,	Hartford, Conn.,	3 Nutting Avenue.
Mack, Walter Adams,	Springfield,	Kappa Gamma Phi.

[1] Work incomplete.

MacLeod, Daniel Johnston,[1]	Wakefield,	Care of S. J. Wright.
Mars, Malcolm Rowe,[1]	Walpole,	20 South College.
Mather, Fred,	Amherst,	Fitts House.
Mayo, Frank Willard,[1]	Houlton, Me.,	120 Pleasant Street.
Mayo, William Irving, Jr.	Framingham,	M. A. C. Farm House.
McRae, Herbert Ranklin,[1]	Malden,	15 Fearing Street.
Merrill, Dana Otis,	Pepperell,	Commons Club.
Moorhouse, Newell,	Worcester,	10 South College.
Nash, Herman Beaman,[1]	Amherst,	R. F. D. No. 1.
Nelson, John Brockway,	Newburyport,	3 Nutting Avenue.
Nims, Homer Willis,	Montague,	Experiment Station.
Noyes, Samuel Verne,	Georgetown,	90 Pleasant Street.
Patton, Willard Ginn,	South Framingham,	M. A. C. Farm House.
Pierce, Harold Barnard,[1]	Kansas City, Mo.,	80 Pleasant Street.
Pike, Chester Arthur,[1]	Smiths,	82 Pleasant Street.
Pratt, Harold Arthur,	Shrewsbury,	Care of Professor Morton.
Quimby, Charles Frederick,	Cape Neddick, Me.,	33 East Pleasant Street.
Randall, Earle MacNeill,	Somerville,	82 Pleasant Street.
Richardson, Lewis Elmer,[1]	Rockville,	82 Pleasant Street.
Ritter, Ernest,	New Britain, Conn.,	88 Pleasant Street.
Rodger, Raymond Miller,	Everett,	90 Pleasant Street.
Rogers, Roland Winsor,	Roxbury,	25 Lincoln Avenue.
Rorstrom, Hans Alfred,	Boston,	82 Pleasant Street.
Rosequist, Birger Reignold,	Brockton,	85 Pleasant Street.
Ross, Louis Warren,[1]	Arlington,	120 Pleasant Street.
Rutter, Walter Frederick,[1]	Lawrence,	17 Fearing Street.
Saidel, Harry Samuel,[1]	Worcester,	3 Nutting Avenue.
Sargent, George Leonard,[1]	Merrimac,	17 Kellogg Avenue.
Sauter, John Martin,	Turners Falls,	60 Pleasant Street.
Saville, William, Jr.,	Waban,	6 South College.
Schaefer, Leonard Charles,[1]	Amherst,	Entomology Building.
Schwab, Andrew Nathan,[1]	Yalesville, Conn.,	M. A. C. Plant House.
Scott, George Alvin,	Clinton,	36 North Prospect Street.
Shumway, Paul Edward,[1]	Greenfield,	60 Pleasant Street.
Sims, James Stanley,[1]	Melrose,	120 Pleasant Street.
Smith, Herbert Dwight,	Poughkeepsie, N. Y.,	Care of E. N. Davis.
Smith, Philip Lawrence,[1]	Kingston,	5 Sunset Avenue.
Smith, Richard Woodworth,	Pittsfield,	96 Pleasant Street.
Spaulding, Almon Whitney,	Dorchester,	18 Nutting Avenue.
Squires, Paul Revere,[1]	Belchertown,	Belchertown.
Stackpole, Frank Charles,[1]	Somerville,	82 Pleasant Street.
Stearns, Carlton McIntyre,	Melrose,	5 Nutting Avenue.
Stiles, Albert Ralph,	Arlington,	36 North Prospect Street.
Stjernlof, Axel Uno,	Worcester,	Brooks Farm.
Stowell, Harold Thurber,	Amherst,	193 South Pleasant Street.
Sturtevant, Warner Butterfield,	Springfield,	14 Nutting Avenue.
Swift, Raymond Walter,	North Amherst,	76 Summer Street.
Thayer, William Wallace,[1]	Somerville,	Care of Mr. Green, Mount Pleasant.
Tuthill, Samuel Fuller,	Mattapoisett,	M. A. C. Farm House.
Upson, Everett Langdon,[1]	New Britain, Conn.,	87 Pleasant Street.
Walbridge, Henry Blood,	Bennington, Vt.,	M. A. C. Farm House.
Warner, Merrill Pomeroy,	Sunderland,	5 South College.
Warren, Harold Manson,[1]	Melrose,	5 McClellan Street.
Warren, James Joseph,	North Brookfield,	35 North Prospect Street.
Webster, Frank Cedric,	Harvard,	82 Pleasant Street.
Westman, Robert Clayton,	Roslindale,	Kappa Gamma Phi.
Whitcomb, Warren Draper,	Waltham,	88 Pleasant Street.
Whitney, Joseph Fradley,[1]	Brooklyn, N. Y.,	96 Pleasant Street.
Wilber, Charles Raymond,	Walpole,	Care of Professor Sears.
Williams, Arthur Franklin,	Sunderland,	7 South College.
Williams, Herbert Clifton,	South Hadley Falls,	29 Pleasant Street.

[1] Work incomplete.

Freshman Class.

Additon, Elizabeth Emery,[1]	Newtonville,	Draper Hall.
Allen, Amos Lawrence,	Dalton,	35 North Prospect Street.
Allen, Leland Christy,	Holyoke,	75 Pleasant Street.
Allen, Ralph Emerson,	Everett,	17 Phillips Street.
Babbitt, Frank Madison,	Fairhaven,	M. A. C. Farm House.
Bainbridge, Frank,	Paterson, N. J.,	Care of Mr. Whittier, Mount Pleasant.
Baker, Foster Kenneth,	Fairhaven,	116 Pleasant Street.
Baker, Henry Raymond,	Amherst,	West Street.
Barbour, Francis Collin,	Hartford, Conn.,	87 Pleasant Street.
Barton, George Wendell,	North Sudbury,	36 North Prospect Street.
Baxter, Herbert Hill,	Brighton,	15 Phillips Street.
Beadle, Herbert Ocumpaugh,	Lima, N. Y.,	6 Phillips Street.
Bennett, Edgar Stearns,[1]	Blackstone,	42 McClellan Street.
Binks, Frank Joseph,[1]	Maynard,	29 North Prospect Street.
Bolster, Rolfe Nelson,[1]	Worcester,	15 Phillips Street.
Boyd, Robert Lucius,[1]	Lynn,	Kappa Gamma Phi.
Brigham, Sylvia Bowen,	Newtonville,	Draper Hall.
Brown, Robert Edward,[1]	Sharon,	36 North Prospect Street.
Bruce, Walter Griffith,	Springfield,	21 Fearing Street.
Burtch, Chester Swan,	Hopkinton,	77 Pleasant Street.
Cameron, Walter Leslie,	Palmer,	66 Pleasant Street.
Canlett, Franklin Harwood,	Bedford,	28 Northampton Road.
Capen, Howard Boyden,	Canton,	Brooks Farm,
Carlson, Fred Albert,	Pittsfield,	84 Pleasant Street.
Carter, Thomas Edward,	West Andover,	Brooks Farm.
Chambers, Roger James,	Dorchester,	6 Nutting Avenue.
Chapman, John Alden,	Salem,	83 Pleasant Street.
Chefferds, Louis David,	Worcester,	1 South College.
Clapp, Roger Francis,	Salem,	17 Phillips Street.
Clark, Stewart Sandy,[1]	Holyoke,	5 Nutting Avenue.
Davis, Dwight Shaw,	Ayer,	31 East Pleasant Street.
Drummond, Joseph Lawrence,[1]	Holyoke,	4 Chestnut Street.
Dubois, George Arthur,	Fall River,	17 Fearing Street.
Duncan, George James,	Arlington,	3 Nutting Avenue.
Durfee, Norman Owen,[1]	Fall River,	79 Pleasant Street.
Edes, David Oliver Nourse,	Bolton,	35 East Pleasant Street.
Ellis, Ralph Chick,[1]	West Newton,	6 Phillips Street.
Emmerich, Louis Philip,	Paterson, N. J.,	Mount Pleasant.
Erickson, George Edwin,	Brockton,	21 Fearing Street.
Faber, Edward Stuart,	Plainfield, N. J.,	Care of S. J. Wright.
Fairchild, Robert Dunning,	Newtown, Conn.,	30 North Prospect Street.
Faneuf, Leo Joseph,	West Warren,	Brooks Farm.
Farrar, Delwin Bruce,	Amherst,	1 Dana Street.
Fellows, Harold Carter,	Peabody,	6 Phillips Street.
Ferriss, Samuel Boynton,	New Milford, Conn.,	4 Chestnut Street.
Fletcher, Walter Greene,	Newton,	53 Lincoln Avenue.
Foley, William Albert,	Palmer,	35 North Prospect Street.
Foster, Hamilton Knight,	New Rochelle, N. Y.,	24 Beston Street.
Foster, Roy Wentworth,	Lynn,	56 North Pleasant Street.
Frellick, Arthur Lester,	Everett,	17 Phillips Street.
Fuller, Camille Baldwin,	West Quincy,	17 Phillips Street.
Garvey, Mary Ellen Monica,	Amherst,	27 South Prospect Street.
Gasser, Thomas Jefferson,	Uxbridge,	Care of Professor Morton.
Gifford, Flavel Mayhew,	West Tisbury,	6 Nutting Avenue.
Gilbert, Howard Goodwin,[1]	Beverly,	15 Hallock Street.
Gillette, Nathan Warner,	Revere,	35 East Pleasant Street.
Goodridge, George Lucien,	Melrose,	53 Lincoln Avenue.
Goodwin, William Irving,	Haverhill,	Brooks Farm.

[1] Work incomplete.

Gordon, Frederick George,	Plymouth,	Care of Mrs. Taber, North Amherst.
Grayson, Forrest,	Milford,	Care of Professor Morton.
Haines, Foster Kingsley,	Peabody,	7 Nutting Avenue.
Hance, Forrest Sansbury,	Paterson, N. J.,	Care of Mr. Whittier, Mount Pleasant.
Harwood, Ralph Wallace,	Barre,	66 Pleasant Street.
Hawley, Robert Dorman,	Springfield,	15 Phillips Street.
Higgins, Leo Clement,	Amesbury,	116 Pleasant Street.
Holmes, George Frederick,[1]	Ipswich,	60 Pleasant Street.
Holmes, Robert Palmer,	Wakefield,	Brooks Farm.
Howard, Arthur Merchant,	Pittsfield,	84 Pleasant Street.
Howe, Albert Edward,[1]	Needham,	3 Phillips Street.
Howe, George Cole,	Worcester,	Care of Professor Morton.
Howes, Donald Francis,	Ashfield,	Brooks Farm.
Hunnewell, Paul Fiske,[1]	West Somerville,	13 Phillips Street.
Huntoon, Douglas Henderson,	Norwood,	7 Nutting Avenue.
Hurlburt, Ralph Walter,[1]	Ashley Falls,	94 Pleasant Street.
Ingalls, Irving Weaver,	Brooklyn, N. Y.,	21 Fearing Street.
Irvine, Robert Patterson,	Wilmette, Ill.,	60 Pleasant Street.
Jenks, Albert George,[1]	Norton,	12 Cottage Street.
Johnson, Birger Lars,	Dorchester,	29 McClellan Street.
Johnson, Sidney Clarence,	Gloucester,	13 Phillips Street.
Jones, Forrest Dean,	Worcester,	120 Pleasant Street.
Jones, Harold Ellis,	New Canaan, Conn.,	Care of E. F. Gaskill.
Jones, Leon Dudley,	Worcester,	120 Pleasant Street.
Kennedy, Carl Francis,[1]	Milford,	Care of Professor Morton.
Kirkham, Philip Leffingwell,[1]	Springfield,	7 Nutting Avenue.
Knight, Frank Edward,[1]	Brimfield,	58 North Pleasant Street.
Lanphear, Marshall Olin,	Windsor, Conn.,	35 East Pleasant Street.
Lasker, David,	Hyde Park,	38 Cottage Street.
Lawrence, Lewis Henry,	Falmouth,	83 Pleasant Street.
Lawton, Ralph Wilber,[1]	Fall River,	75 Pleasant Street.
Leiper, McCarrell Hudson,	Blauvelt, N. Y.,	116 Pleasant Street.
Levine, Darwin Solomon,	Sherborn,	38 Cottage Street.
Lipshires, David Mathew,	Winter Hill,	14 Nutting Avenue.
Loring, William Rupert,	Housatonic,	94 Pleasant Street.
Lusk, John Isaiah,	Marlborough,	7 High Street.
Lyons, Louis Martin,	Norwell,	29 North Prospect Street.
Maginnis, John Joseph,	Lawrence,	35 North Prospect Street.
Mallorey, Alfred Sidney,	Lynn,	15 Hallock Street.
Marshall, Max Skidmore,	Amherst,	44 Sunset Avenue.
Mather, William,	Amherst,	Fitts House.
McClellan, Adams Newton,[1]	Keene, N. H.,	35 East Pleasant Street.
McKechnie, Donald,	Sharon,	Brooks Farm.
McKee, William Henry,	Chelsea,	Brooks Farm.
Messenger, Kenneth Leroy,	Winsted, Conn.,	35 East Pleasant Street.
Millard, Harold Baldwin,	Great Barrington,	5A East Pleasant Street.
Minor, John Bacon, Jr.,	Plainville, Conn.,	79 Pleasant Street.
Mitchell, Edward Nahum,	Medford,	36 North Prospect Street.
Mitchell, Theodore Bertis,	Needham,	Brooks Farm.
Mower, Carl Taft,	Montpelier, Vt.,	35 East Pleasant Street.
Newton, Edward Buckland,	Holyoke,	5 Nutting Avenue.
Newton, Gaylord Arthur,	Durnham, Conn.,	3 Fearing Street.
Norcross, Gardner Clyde,	Brimfield,	58 North Pleasant Street.
Odams, Lester Nichols,[1]	Salem,	120 Pleasant Street.
O'Neill, Oliver Maurice,	Dorchester,	16 Pleasant Street.
Patch, Lawrence Henry,	Wenham,	120 Pleasant Street.
Petit, Arthur Victor,	Amherst,	31 East Pleasant Street.
Phipps, Clarence Ritchie,	Dorchester,	77 Pleasant Street.
Powell, James Congdon,	Newport, R. I.,	77 Pleasant Street.
Pratt, Oliver Goodell,	Salem,	17 Phillips Street.

[1] Work incomplete.

Preble, John Nelson,	Jamaica Plain,	42 McClellan Stieet.
Randall, Waring Eugene,[1]	Belchertown,	Belchertown.
Raymond, Clinton Rufus,	Beverly,	35 North Prospect Street.
Reumann, Theodore Henry,	New Bedford,	31 East Pleasant Street.
Richardson, Stephen Morse,	Marlborough,	South College.
Robbins, Waldo Whiting,	Hingham,	53 Lincoln Avenue.
Roberts, Oliver Cousens,	Boston,	36 North Prospect Street.
Robinson, William Herbert,	Lynn,	56 North Prospect Street.
Russell, Howard Leigh,	Worcester,	116 Pleasant Street.
St. George, Raymond Alexander,	Lynn,	15 Hallock Street.
Sampson, Fred Bucknam,[1]	Fall River,	60 North Pleasant Street'
Sanborn, Deane Waldron,	Nantucket,	Care of S. J. Wright.
Sawyer, Wesley Stevens,	Boston,	42 McClellan Street.
Sawyer, William George,	Berlin,	Care of S. J. Wright.
Schlough, George Homer,	Waltham,	31 East Pleasant Street.
Seavey, Arthur Jones,	New Braintree,	Pease Avenue.
Sedgwick, Alfred,[1]	Fall River,	116 Pleasant Street.
Sliski, John,	Springfield,	– –
Smith, Carleton Tower,	West Newton,	116 Pleasant Street.
Smith, Sidney Sumner,	Boston,	32 North Prospect Street.
Spaulding, Lewis Winans,[1]	South Hingham,	Care of Professor Morton.
Spencer, Arthur Winthrop,	Danvers,	12 Cottage Street.
Stanton, Frank Parker,	Revere,	35 East Pleasant Street.
Stickney, Stephen Arthur,	West Peabody,	7 Nutting Aveuue.
Stowe, Raymond Timothy,	Enfield, Conn.,	35 East Pleasant Street.
Stowers, Addison Clifford,	Dorchester,	15 Phillips Street.
Strong, William Perkins,[1]	South Hadley Falls,	Pine Street, North Amherst.
Sullivan, Harold Leo,	Lawrence,	35 North Prospect Street.
Sutherland, Ralph,	Cambridge,	77 Pleasant Street.
Swift, Hubbard,	West Falmouth,	83 Pleasant Street.
Thayer, Weston Cushing,	Hingham,	53 Lincoln Avenue.
Thompson, Wells Nash,	Adams,	79 Pleasant Street.
Thorpe, Richard Warren,	West Medford,	17 Cottage Street.
Tilton, Arthur Dana,	Wellesley,	15 Phillips Street.
Tucker, Lee Heston,	Ware,	8 North College.
Underwood, Arthur Leslie,	Stow,	35 East Pleasant Street.
vanAlstyne, Lewis Moriell,	Kinderhook, N. Y.,	35 East Pleasant Street.
Vickers, John,	Deerfield,	36 North Prospect Street.
Warren, Wesley Raymond,	Worcester,	15 Phillips Street.
Weeks, Roger Wolcott,	Hyde Park,	35 East Pleasant Street.
Wilbur, Laurence Weston,	South Middleborough,	23 East Pleasant Street.
Willoughby, Raymond Royce,	Newtington, Conn.,	24 Beston Street.
Wolfson, Louis Elijah,	Malden,	38 Cottage Street.
Woodbury, Ray Willard,[1]	Newburyport,	Care of H. G. Russell, Cottage Street.
Wooding, Paul Bennett,[1]	Yalesville, Conn.,	35 East Pleasant Street.
Woods, Frank Archibald,	Groton,	5 Nutting Avenue.
Woodworth, Brooks,	Lowell,	6 Nutting Avenue.
Worthley, Harlan Noyes,	Greenwood,	14 Nutting Avenuc.
Wright, John Lindsey,[1]	Putnam, Conn.,	77 Pleasant Street.
Yesair, John,	Byfield,	36 North Prospect Street.

Unclassified Students.

Brawn, Howard Drown,	Mansfield,	32 North Prospect Street.
Derby, Llewellyn Light,	Hudson,	35 East Pleasant Street.
Dillon, Thomas Stevenson,[1]	West Warren,	35 East Pleasant Street.
Fellows, Katharine Adelheid,	Northampton,	21 Amity Street.
Floyd, Fred Gillan,	West Roxbury,	9 Fearing Street.
Fraser, Charles Allen,	Plymouth,	35 East Pleasant Street.
Hartwell, Herford Carter,	Somerville,	75 Pleasant Street.
Higgins, Lloyd Hale,	Provincetown,	31 North Prospect Street.

[1] Work incomplete.

Hill, Donald Russell,	Arlington,	29 McClellan Street.
Leonard, Nelson Ellsworth,	Raynham Center,	30 North Prospect Street.
Lindsley, Horace Nelson,[1]	Orange, N. J.,	120 Pleasant Street.
Lydiard, Carl Harold,	Boston,	3 Phillips Street.
Martin, Thomas James,	Holyoke,	60 Pleasant Street.
McLean, George Robert,	Northampton,	60 Washington Avenue, Northampton.
McMurray, Charles Joseph,	West Fitchburg,	42 McClellan Street.
McNamara, Michael Joseph,	Stoughton,	35 East Pleasant Street.
Mooradkanian, Gregory,	Lawrence,	Hillside Avenue, R. F. D. No. 126.
Murrin, James Patrick,	Dorchester,	79 Pleasant Street.
Newton, Raymond Lovejoy,[1]	Malden,	29 McClellan Street.
O'Brien, Patrick,	Pittsfield,	60 Pleasant Street.
Parker, Judson Lanphere,	Holyoke,	56 North Pleasant Street.
Pierce, Harry Walker,	West Medford,	3 McClellan Street.
Richardson, Royal Phelps,	Scituate,	29 McClellan Street.
Robinson, Edward Hosmer,	Malden,	3 McClellan Street.
Rugg, Arthur Prentice, Jr.,	Worcester,	Care of Professor Morton.
Russell, Edward Stanton,	New Haven, Conn.,	73 Pleasant Street.
Studley, Robert Allan,	Rockland,	116 Pleasant Street.
Talbot, Marjorie,	Roxbury,	9 Phillips Street.
Tuttle, George Raymond,	Waltham,	Care of E. F. Gaskill.
Upham, Harlan Willis,[1]	Thornton's Ferry, N. H.,	8 Allen Street.
Winchester, George Taylor,	Woburn,	75 Pleasant Street.
Winter, Henry George,[1]	Ashburnham,	120 Pleasant Street.

Summary by Classes.

Graduate students,	52
Senior class,	103
Junior class,	113
Sophomore class,	142
Freshman class,	168
Unclassified students,	32
Total registration,	610

Geographical Summary.

Massachusetts,	500
Connecticut,	35
New York,	24
New Jersey,	10
Pennsylvania,	6
New Hampshire,	6
Maine,	5
Vermont,	5
Ohio,	3
Rhode Island,	3
Canada,	2
Barbados,	1
China,	1
Delaware,	1
Illinois,	1
India,	1
Japan,	1
Michigan,	1
South America,	1
Virginia,	1
Wisconsin,	1
Wyoming,	1
Total,	610

[1] Work incomplete.

Short Course Students.

The Ten Weeks' Course.

Adams, Henry L.,	Elmwood.
Alstrom, Edwin H.,	Springfield.
Anderson, Mrs. Ernest,	Amherst.
Armstrong, Anna W.,	East Sandwich.
Atwell, Lewis,	South Framingham.
Bacon, R. D.,	Worcester.
Barker, Harry S.,	Littleton.
Barnard, F.,	Northampton.
Barnes, James,	Yalesville, Conn.
Beckwith, Wm.,	Springfield, Vt.
Bemis, Ralph A.,	Spencer.
Bliss, Walter C.,	Springfield.
Borden, Aubrey W.,	South Framingham.
Botsford, H. E.,	Petersham.
Boynton, Paul J.,	Ausable Forks, N. Y.
Bradford, Clarendon A.,	North Dorset, Vt.
Bridgman, Gertrude L.,	South Amherst.
Brown, Mrs. M. W.,	Windsor.
Bronson, Wesley H.,	Marlborough.
Bryan, Bart E.,	West New Brighton, N. Y.
Buck, Edgar H.,	Warren.
Burnham, William I.,	Lexington.
Burns, James J.,	Meriden, Conn.
Buswell, Elmer N.,	Boston.
Butterfield, Lawrence D.,	Lexington.
Buxton, Ralph O.,	Saugus.
Carroll, A. Sidney,	Hartford, Conn.
Cathie, Harold,	Needham.
Chase, Mrs. Clara,	Greenfield.
Chase, Harry E.,	South Framingham.
Clark, Jesse H.,	Malden.
Clarke, Stanley,	Winchester.
Clarke, Mrs. Stanley,	Winchester.
Coe, Ernest A.,	Greenwich, Conn.
Copeland, Robert A.,	Townsend.
Coppinger, Edward,	Needham Heights.
Corey, Eben Fox,	Boston.
Cotter, William,	Salem.
Creesy, Richard L.,	Brookline.
Cresta, Nicholas,	Haydenville.
Cunningham, John A.,	Dorchester.
Curley, John I.,	Holyoke.
Cushman, Burt A.,	Bernardston.
Cushman, R. F.,	Sylvania, O.
Cutler, Paul E.,	Boylston.
Dana, Alfred L.,	Amherst.
Dascomb, Jean,	Westminster, Vt.
Davis, P. I.,	Chestnut Hill.
Dawson, Harry Custer,	Tewksbury.
Diaz, Mrs. Ralph M.,	Belmont.
Diaz, Ralph M.,	Belmont.

Dickinson, Richard S.,	Granville.
Dickinson, W. L.,	Helena, Mont.
Dimock, Dwight L.,	Billerica.
Doten, Clarence A.,	Lincoln.
Ely, Ralph A.,	Holyoke.
Everson, Carroll W.,	Amherst.
Everson, Wesley E.,	West Hanover.
Farrar, Marion A.,	South Framingham.
Fellows, Katharine A.,	Northampton.
Fisher, Austin L.,	North Amherst.
Fiske, Wm. M.,	Northampton.
Fitton, Willard S.,	Dorchester.
Flagg, E. M.,	Florence.
Foster, Charles H.,	North Andover.
Frye, Caleb B.,	Dorchester.
Gale, Lawrence S.,	Charlemont.
Gifford, J. E.,	Danvers.
Glazier, H. E.,	Andover.
Gordon, Harrington M.,	Auburndale.
Graves, Charles E.,	Haydenville.
Green, H. L., Jr.,	Worcester.
Greenwood, L. J.,	Billerica.
Gregson, B. N.,	Boston.
Harthan, Harold C.,	West Boylston.
Hastings, M. Leroy,	Whitinsville.
Hawks, Paul,	Deerfield.
Hayden, Luman H.,	Hudson.
Heald, Philip C.,	Greenville, N. H.
Hemenway, C. M.,	Williamsburg.
Herrick, Clifton H.,	Raynham.
Herrick, Frank L.,	Brookline.
Higgins, Edward L.,	North Billerica.
Hinman, Wilbur S.,	Bennington, Vt.
Holden, Lester,	Shirley.
Holmes, Arthur C.,	Kingston.
Hopkins, Chas. Warner,	Brattleboro, Vt.
Howe, Harold H.,	Kingston.
Hunter, R. D.,	West Claremont, N. H.
Hopkinson, H. B.,	Cambridge.
Irons, Marion R.,	Boston.
Keith, Russell S.,	East Bridgewater.
Kenyon, S. W.,	New Bedford.
Killam, John,	East Boxford.
Klang, M. I.,	East Canaan, Conn.
Lathrop, Benson M.,	Pittsfield.
Lefevre, Herbert T.,	Jamaica Plain.
Lehr, F. L., Jr.,	New Haven, Conn.
Le Provost, Lyle F.,	Lee.
Littlefield, Ray Leon,	Auburn.
Lorion, E. H.,	Worcester.
Lyons, Thomas E.,	Worcester.
Martin, Ralph,	Montague.
Merrell, Charles E.,	West Somerville.
Merrell, Ralph,	Suffield, Conn.
Milk, Mrs. M. E.,	South Amherst.
Miller, Donald H.,	Whitman.
Mumford, W. C.,	Springfield.
Newhall, Hermann A.,	Sterling Junction.
Nicholls, Raymond F.,	Northampton.
Norrman, Karl A.,	Lynn.
O'Donnell, Ambrose,	Jamaica Plain.
O'Donnell, J. C.,	Belchertown.
Parsons, Earle M.,	Northampton.
Parsonson, Alfred H.,	Peabody.

Partridge, Francis A., Jr.,	Woburn.
Pearmain, John D.,	Framingham.
Platt, Clarence I.,	Milford, Conn.
Post, Charles L.,	Great Barrington.
Potter, Roger W.,	Worcester.
60 Putney, Luther R.,	Marblehead.
Record, Harold J.,	West Boylston.
Rich, Alton F.,	Winthrop.
Rooney, Nelson L.,	Bedford.
Ropes, Ernest C.,	Boston.
Ropes, Mrs. Nathalie W.,	Boston.
Roundy, Perley B.,	Beverly.
Russell, Ivo A.,	Concord Junction.
Russell, Raymond M.,	Quincy.
Russell, Mrs. Renouf,	Keene, N. H.
Russell, Renouf,	Keene, N. H.
Sanders, Eugene,	Wollaston.
Sandford, Geo. T.,	Plattsburg, N. Y.
Sanford, Raymond,	Plattsburg, N. Y.
Sawyer, Henry A.,	Worcester.
Scott, Keith,	Brookline.
Shaw, W. F.,	Orange.
Siech, P. H.,	Springfield.
Silk, Jack,	Lowell.
Sinclair, Harrop S.,	Northampton.
Skillings, Mrs. D. U.,	Amherst.
Smith, Allison P.,	Cambridge.
Smith, Bowdoin B.,	East Weymouth.
Snoji, Shiina,	Japan.
Snyder, Henry H.,	Cummington.
Stentiford, Henry,	Irvington, N. Y.
Stevens, Edward Reed,	Worcester.
Stiles, Lawrence,	Amherst.
Stone, Frederick T.,	Chelsea.
Stoughton, Philip,	Montague.
Sussmann, Rudolph,	Sharon.
Talty, T. L.,	Boston.
Tappan, Cushing,	Cambridge.
Teplenke, I.,	Raynham Center.
Thornburg, Paul,	Ashland, O.
Tinkham, W. Earle,	North Raynham.
Totman, William,	Bardwell's Ferry.
Trull, Larkin T., Jr.,	Lowell.
Turner, Miss A. C.,	Quincy, Ill.
Turner, Ralph C.,	Amherst.
Tyler, John,	Brookline.
Tyler, Mrs. John,	Brookline.
Urbaitis, Frank,	Worcester.
Van Valkenburgh, Hugh,	State Line.
Veprek, Vencenc,	Springfield.
Wade, Francis C.,	West Newbury.
Walker, Henry P.,	Hudson.
Walsh, Henry J.,	Kingston.
Walsh, Lloyd,	Amherst.
Wells, Collin,	Hanover, N. H.
Wendel, Mrs. Theodore,	Ipswich.
Whitlock, Aaron B.,	Warehouse Point, Conn.
Whitman, Frank L.,	Griswoldville.
Wilbur, W. A.,	Lanesborough.
Wilcox, Ralph Henry,	Middletown, Conn.
Willard, Winn,	Cambridge.
Williams, G. R.,	Northampton.
Wilson, Harry C.,	East Lynn.
Wood, Charles A.,	Central Village.

Wood, Oliver W.,	Arlington.
Yale, David H.,	Meriden, Conn.
Young, Harold B.,	Yalesville, Conn.

Apple Packing School.

Anderson, O. G.,	East Pepperell.
Bagnell, Fred,	Mount Hermon.
Barnard, Perley D.,	Contoocook, N. H.
Barnard, Raymond J.,	Contoocook, N. H.
Barton, Hubert C.,	South Amherst.
Burke, E. J.,	Hadley.
Castle, F. A.,	Springfield.
Chase, Edith E.,	Stuyvesant, N. Y.
Chase, H. W.,	Cambridge.
Churchill, Mrs. W. W.,	Milton.
Clarke, Lulu E.,	Milton, N. Y.
Davis, Irving G.,	Brimfield.
Doolittle, Albert W.,	Concord Junction.
Elder, David,	Northampton.
Ely, Ralph,	Holyoke.
Frost, H. I.,	Ashby.
Hall, Russell B.,	Medway.
Hulst, Alfred N.,	Amherst.
Leach, C. Arthur,	South Hamilton.
Lindstrom, Mrs. C. R.,	Fayville.
Neall, N. J.,	Boston.
Parker, Chas. M.,	Brookfield.
Porter, Wm. J.,	Groton.
Powers, Frank A.,	Bolton.
Ryan, John C.,	Bennington, Vt.
Taber, L. I.,	Mount Hermon.
Taplin, W. H.,	Brighton.
Whitelock, Wm. M. E.,	Marlborough.

School for Tree Wardens.

Ames, John S.,	North Easton.
Ball, L. P.,	Winchendon.
Benoit, Piesee,	Southbridge.
Brown, Penwal S.,	Scituate.
Bragg, J. W.,	Greenfield.
Bray, Thomas A.,	Holyoke.
Brown, John W.,	Brimfield.
Colton, Wm. W.,	Fitchburg.
Dodge, A. W., Jr.,	Wenham.
Gibbs, R. M.,	Salem.
Hale, Warren F.,	Salem.
Jones, Martin A.,	Northfield.
McCullough, John J.,	Melrose.
McLaughlin, J. H.,	Millers Falls.
Neale, Harold J.,	Worcester.
O'Connell, M. H.,	Millers Falls.
Riley, E. E.,	Needham.
Rust, C. N.,	Granby.
Sawtelle, B. A.,	Greenwich.
Taplin, W. H.,	Brighton.
Whitney, Geo. A.,	Athol.
Worth, Herbert J.,	Gloucester.

Summer School.

Allanbrook, Mabel C.,	Everett.
Avery, Roy C.,	Storrs, Conn.
Ayer, Addie M.,	Richford, Vt.

Armstrong, Mrs. L. V. V.,	Bronxville, N. Y.
Backus, Victor T.,	Center Marshfield.
Baker, Helen L.,	Wollaston.
Ballow, Jessica E.,	Enfield.
Berry, James M.,	Everett.
Beston, Mary,	Amherst.
Billings, Mary A.,	Amherst.
Blanchard, Winifred V.,	Roxbury.
Borleughi, Louis,	South Weymouth.
Bradley, Mrs. Mary R.,	Brookline.
Bradley, Parker R.,	Amherst.
Bridgman, Marion E.,	Amherst.
Bradbeck, Paul E.,	Wollaston.
Brooks, Alice O.,	Quincy.
Brooks, Laura J.,	Stoneham.
Bryant, Bertha W.,	Woburn.
Burnap, Margaret,	Woburn.
Burns, Thorton,	Plymouth.
Buswell, Marion E.,	Dorchester.
Capen, Arthur G.,	Worthington.
Cattanach, Henrietta C.,	Boston.
Challiss, Ada L.,	Bronxville, N. Y.
Chamberlain, Edwin M.,	Amherst.
Chamberlain, Mrs. Mary B.,	Amherst.
Chandler, Lorna M.,	Amherst.
Churchill, Josephine,	Ponkapog.
Clark, Katherine,	North Amherst.
Clark, Mary,	Amherst.
Cooke, Grace H.,	New Haven, Conn.
Cooley, Elsie H.,	Amherst.
Davis, Isabel,	Princeton.
Davis, Malcolm W.,	New York City.
Davis, Rufus E.,	Brockton.
Dawson, Ava B.,	Boston.
Dawson, Una G.,	Boston.
Demond, Grace,	Chicopee Falls.
Dorr, Thomas R.,	Williamstown.
Dyer, Vivian,	Auburndale.
Elwell, Mrs. Sybil M.,	Winthrop.
Emanuel, Max.,	New York City.
Epstein, Ida A.,	Amherst.
Epstein, Rose,	Amherst.
Evans, Augusta D.,	Frackville, Pa.
Farrell, Mrs. Helen W.,	Stoughton.
Fauntleroy, Anne M.,	Northampton.
Fay, Charles R.,	Brooklyn, N. Y.
Fernald, Evelyn I.,	Groton.
Flagg, Sadie E.,	West Berlin.
Floyd, F. G.,	West Roxbury.
Floyd, Mrs. F. G.,	West Roxbury.
Fuller, Gertrude A.,	Boston.
Gates, Ruth D.,	Amherst.
Grant, Winnifred L.,	North Attleborough.
Griggs, Jennie E.,	Plymouth, Conn.
Hall, M. Elizabeth,	Amherst.
Harris, Jessie F.,	Whitman.
Harrison, Mrs. A. K.,	Amherst.
Hatch, Bertha E.,	New Milford.
Hatch, Mary J.,	New Milford.
Hearn, Geo. D.,	Holyoke.
Henry, Margaret Lee,	Norwalk, Conn.
Hickey, Nellie M.,	Sunderland.
Holden, Mrs. Austin,	Boston.
Homor, Eleanor J.,	Stoughton.

Hopkins, Lydia L.,	Leominster.
Howard, Alice M.,	North Amherst.
Howard, Clara B.,	North Amherst.
Hoyt, Mrs. Laura A.,	Greenfield.
Hurd, Mrs. W. D.,	Amherst.
Jacobs, Anita A.,	Greenwich, Conn.
James, Edith,	Montclair, N. J.
Johns, Lois,	Amherst.
Johnson, Phyllis,	Amherst.
Joslin, Miss J. M.,	New York City.
Kelsey, Christina,	West Hartford, Conn.
Kendall, Harley F.,	Springfield.
Kennedy, H. Anna,	South Weymouth.
Kenney, Irene E.,	Amherst.
Kingman, Ruth E.,	Somerville.
Klang, M. I.,	Arlington.
Knowles, Grace Vincent,	Natick.
Lawrence, A. Mae,	Worcester.
Lewis, Mayone,	Philadelphia, Pa.
Linehan, Katherine L.,	New York City.
Lockwood, Julia B.,	Norwalk, Conn.
Maloney, Katherine,	Great Barrington.
Marley, Edna,	Cymryd, Pa.
Mathews, Maud A.,	Fall River.
Maynard, Pearl A.,	West Newton.
Merriam, Ida A.,	Malden.
Middleton, Frederick H.,	Amherst.
Mitchell, Edward A.,	Coppahosic, Va.
Moore, Mary A.,	West Haven, Conn.
Moscouelli, Chrestus,	Boston.
McGuire, Helena M.,	Belmont.
McLean, Geo. R.,	Northampton.
Nickerson, Charlotte W.,	Amherst.
Onthank, Charlotte,	Roxbury.
Partridge, Nelson H., Jr.,	Cambridge.
Patterson, Philip M.,	Springfield.
Phelps, Lyman B.,	Northampton.
Richards, Clinton J.,	Northampton.
Richmond, Florence M.,	Meriden, Conn.
Ruggli, Clara W.,	Cambridge.
Russell, Gladys,	Amherst.
Ryan, Bridget A.,	Sunderland.
Safford, Mrs. F. H.,	Philadelphia, Pa.
Samuel, Elizabeth I.,	Boston.
Sayward, Dorothy R.,	Wollaston.
Schweetzer, Edith E.,	Jamaica Plain.
Schweetzer, Walter,	Jamaica Plain.
Scott, Leslie J.,	Amesbury.
Sears, Mrs. F. C.,	Amherst.
Shaw, Mrs. Bertha T.,	Amherst.
Shearman, Janet C.,	Williamstown.
Sheldon, Ernest M.,	Amherst.
Sheridan, Katherine,	Winchester.
Sheridan, Mrs. G. F.,	Winchester.
Sherman, Roger,	Detroit, Mich.
Smith, Atherton C.,	East Boston.
Smith, Clara N.,	North Amherst.
Smith, Mrs. G. R.,	East Boston.
Smith, Stanley W.,	Boston.
Spencer, Elizabeth,	Bridgeport, Conn.
Spencer, Jessie,	Bridgeport, Conn.
Spencer, Mabel,	Bridgeport, Conn.
Stebbins, Blanche,	Lexington.
Stedman, Geo. A.,	Taunton.

Sullivan, Nellie,	Three Rivers.
Sagickian, John,	East Lynn.
Turner, Mary I.,	South Meriden, Conn.
Unangst, Royal L.,	Hingham.
Waid, Mrs. E. D.,	Amherst.
Walcott, John,	Concord.
Walker, Mrs. L. S.,	Amherst.
Waugh, Edith L.,	Brockton.
Weeks, Gertrude,	Boston.
Welch, Elizabeth A.,	Fall River.
Wheeler, Ethel M.,	Bridgeport, Conn.
Whitely, Ethel C.,	Philadelphia, Pa.
Wheeler, Ethel M.,	Bridgeport, Conn.
Wiggin, Mary P.,	Winchester.
Wright, Stuart E.,	Taunton.
Wright, Elizabeth,	Northampton.

School for Rural Social Service.

Adams, Rev. Raymond,	North Brookfield.
Allen, George E.,	Wendell.
Bottume, Hazel E.,	Windsor Locks, Conn.
Callahan, Julia F.,	Lynn.
Curry, Katherine,	Lynn.
Damon, Geo. H.,	Windsor.
Foster, Rev. E. O.,	Columbia, Conn.
Griffin, J. L.,	Corvallis, Ore.
Hardy, Rev. Owen E.,	North Hadley.
Hawk, Rev. Willis B.,	South Barre.
Howard, E. F.,	East Northfield.
Kebbe, David L.,	Cummington.
Loomis, Herbert N.,	Northampton.
Luce, Robert W.,	Seymour, Conn.
Panunzio, Constantine M.,	Amherst.
Pratt, Rev. Hermann J.,	Granville.
Percy, Rev. C. L.,	Charlton.
Pines, J. Franklin,	Springfield.
Selden, Ruth,	Northampton.
Smith, John F.,	Berea, Ky.
Webb, Daisy,	Amherst.
Willett, A. D.,	Hubbardston.

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Public Document No. 31

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MASSACHUSETTS AGRICULTURAL EXPERIMENT STATION.

PARTS I. AND II.,

BEING PARTS III. AND IV. OF THE FIFTY-SECOND ANNUAL REPORT OF THE MASSACHUSETTS AGRICULTURAL COLLEGE.

JANUARY, 1915.

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PART I.

REPORT OF THE DIRECTOR AND OTHER OFFICERS.

PART II.

DETAILED REPORT OF THE EXPERIMENT STATION.

A RECORD OF THE THIRTY-SECOND YEAR FROM THE FOUNDING OF THE STATE AGRICULTURAL EXPERIMENT STATION.

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OFFICERS AND STAFF.

COMMITTEE.

STATION STAFF.

Administration.

William P. Brooks, Ph.D., *Director*.
Joseph B. Lindsey, Ph.D., *Vice-Director*.
Fred C. Kenney, *Treasurer*.
Charles R. Green, B.Agr., *Librarian*.
Mrs. Lucia G. Church, *Clerk*.
Miss Grace E. Gallond, *Stenographer*.

Agricultural Economics.

Alexander E. Cance, Ph.D., *Agricultural Economist*.

Agriculture.

William P. Brooks, Ph.D., *Agriculturist*.
Henry J. Franklin, Ph.D., *In Charge Cranberry Sub-station*.
Edwin F. Gaskill, B.Sc., *Assistant Agriculturist*.
Robert L. Coffin, *Assistant*.

Chemistry.

Joseph B. Lindsey, Ph.D., *Chemist*.
Edward B. Holland, Ph.D., *Associate Chemist in Charge (Research Section)*.
Fred W. Morse, M.Sc., *Research Chemist*.
Henri D. Haskins, B.Sc., *Chemist in Charge (Fertilizer Section)*.
Philip H. Smith, M.Sc., *Chemist in Charge (Food and Dairy Section)*.
Lewell S. Walker, B.Sc., *Assistant Chemist*.
Rudolf W. Ruprecht, M.Sc., *Assistant Chemist*.
Carleton P. Jones, B.Sc., *Assistant Chemist*.
Walter S. Frost, B.Sc., *Assistant Chemist*.
James P. Buckley, Jr., *Assistant Chemist*.
James T. Howard, *Inspector*.
Harry L. Allen, *Assistant in Laboratory*.
James R. Alcock, *Assistant in Animal Nutrition*.
Miss Alice M. Howard, *Clerk*.
Miss Rebecca L. Mellor, *Clerk*.

Entomology. Henry T. Fernald, Ph.D., *Entomologist.*
Burton N. Gates, Ph.D., *Apiarist.*
Arthur I. Bourne, A.B., *Assistant Entomologist.*
Miss Bridie E. O'Donnell, *Clerk.*

Horticulture. Frank A. Waugh, M.Sc., *Horticulturist.*
Fred C. Sears, M.Sc., *Pomologist.*
Jacob K. Shaw, Ph.D., *Research Pomologist.*
John B. Norton, B.Sc., *Graduate Assistant.*

Meteorology. John E. Ostrander, A.M., C.E., *Meteorologist.*
R. E. McLain, *Observer.*

Microbiology. Charles E. Marshall, Ph.D., *Microbiologist.*
F. H. Hesselink van Suchtelen, Ph.D., *Research Microbiologist.*

Poultry Husbandry. John C. Graham, B.Sc., *Poultry Husbandman.*
Hubert D. Goodale, Ph.D., *Research Biologist.*
Miss Marcella C. Curry, *Clerk.*

Vegetable Physiology and Pathology. George E. Stone,[1] Ph.D., *Vegetable Physiologist and Pathologist.*
A. Vincent Osmun, M.Sc., *Acting Head of Department.*
George H. Chapman, M.Sc., *Research Vegetable Physiologist.*
Orton L. Clark, B.Sc., *Assistant Vegetable Physiologist and Pathologist.*

Veterinary Science. James B. Paige, B.Sc., D.V.S., *Veterinarian.*
George E. Gage, Ph.D., *Research Pathologist.*
Miss Beryl H. Paige, A.B., *Assistant.*

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[1] On leave.

REPORT OF THE DIRECTOR.

WM. P. BROOKS.

ADMINISTRATION.

Station Staff.

During the past year but few changes occurred in station staff, and none in the personnel in the positions of chief responsibility. The following should be mentioned: —

The place of Chas. E. Ward in the trustees' committee on the experiment station, made vacant by his resignation in August, was filled by the appointment of his successor on the Board of Trustees — Mr. Edmund Mortimer of Grafton — to membership in the experiment station committee.

Dr. J. B. Lindsey, vice-director and head of the department of chemistry, was granted leave of absence on account of ill health from June 20 until September 1, and during his absence Mr. F. W. Morse served as vice-director and Mr. E. B. Holland as head of the chemical department.

Dr. Geo. E. Stone was granted leave of absence on account of ill health in October, and this leave still continues. Prof. A. Vincent Osmun was appointed acting head of the department of vegetable physiology and pathology.

Mr. Geo. H. Chapman, after eight months' leave of absence for study and investigation abroad, resumed his duties on May 1. Mr. Orton L. Clark, employed in the department of vegetable physiology and pathology during Mr. Chapman's absence, was appointed assistant in the department on Dec. 1, 1913, taking the place of Mr. Edw. A. Larrabee, whose resignation took effect on February 28.

Mr. John W. Sayer, foreman in the experimental poultry yards, resigned September 30. His work is now carried on by Mr. Austin Brown, who has not, however, yet received formal appointment to the position of foreman.

Miss F. Ethel Felton, first clerk in the department of chemistry, resigned in August, and Miss A. M. Howard was promoted to the position of first clerk. Since the promotion of Miss Howard, Miss Rebecca L. Mellor has given full time to the work of the department of chemistry.

R. E. McLain has succeeded E. K. Dexter as observer in the meteorological department.

Maintenance.

The most important change affecting the revenues of the experiment station during the past year has been the increase of $5,000 provided by act of Legislature in 1913. There is also a considerable increase in the receipts in the chemical department for analytical work, cow testing, etc., and in the amount received for analysis fees under the fertilizer law. On the other hand, the revenue from the sale of fruit from the cranberry bog in East Wareham, on account of relatively small yield and low prices, is about $3,000 less than in 1913. The total revenues are shown in the following table: —

Total Revenue for the Fiscal Year, Dec. 1, 1913, to Dec. 1, 1914.

State appropriation,	$20,000 00
Federal appropriations: —	
Hatch fund,	15,000 00
Adams fund,	15,000 00
Agricultural department, sales and labor,	2,494 49
Chemical department, analytical work, cow testing, etc.,	10,013 33
Fertilizer law, analysis fees,	11,112 00
Feed law, State appropriation,	6,000 00
Cranberry substation: —	
Sale of fruit,	2,511 86
Sale of vines,	17 50
Prizes,	10 00
Meteorological observations, scientific services, etc.,	137 50
Graves' orchard: —	
Sale of fruit,	129 25
Total,	$82,425 93

The aggregate total revenue exceeds the aggregate for the last year to the amount of $3,182.61. The total required in the execution of the feed and fertilizer laws amounted to

$15,272.66. These expenditures in detail are shown in subsequent pages. The total current revenue available for general administration and investigation, therefore, amounted to $67,153.27.

The treasurer's report in full will be found on pages 28 *a* and 29 *a*.

Fertilizer Law Account.

Dec. 1, 1913, to Nov. 30, 1914.

Balance Dec. 1, 1913,		$1,467 96	
Fertilizer fees,		11,112 00	
Total,			$12,579 96

Expenditures.

Collection expenses: —			
Inspector's salary,	$670 00		
Inspector's traveling expenses,	627 02		
		$1,297 02	
Salaries: —			
Chemists,	$5,446 68		
Clerical,	399 00		
		5,845 68	
Labor: —			
Miscellaneous (laboratory assistance),	$149 00		
Janitor,	153 44		
		302 44	
Chemicals and apparatus,		645 36	
Heat and light (gas),		136 51	
Laundry,		13 02	
Office supplies,		132 88	
Miscellaneous,		72 97	
Library,		6 00	
Publications: —			
Bulletin No. 147,	$794 27		
Mailing,	3 60		
		797 87	
Official traveling,		124 98	
Fertilizer experiments: —			
Labor and materials,	$326 80		
Rent,	25 00		
		351 80	
Total,			9,726 53
Balance Dec. 1, 1914,			$2,853 43

Feed Control Account.

Dec. 1, 1913, to Nov. 30, 1914.

Balance Dec. 1, 1913,		$916 07	
Appropriation,		6,000 00	
Total,			$6,916 07

Expenditures.

Collection expenses: —			
Inspector's time,	$330 00		
Inspector's traveling expenses,	377 40		
		$707 40	
Salaries (chemical and clerical),		3,448 30	
Labor (janitor),		94 95	
Heat and light,		38 38	
Laboratory apparatus,		154 14	
Chemicals,		74 72	
Office supplies,		40 85	
Expert service: —			
Legal,	$78 27		
Stenographic,	18 75		
		97 02	
Official traveling,		110 78	
Minor repairs,		18 14	
Sundries,		17 99	
Library,		5 00	
Publications: —			
Bulletin No. 146,	$565 71		
Control Bulletin No. 1,	469 00		
Mailing,	12 55		
		1,047 26	
Furniture and fixtures,		43 00	
Total,			5,897 93
Balance Dec. 1, 1914,			$1,018 14

Publication.

During the past year an important change has been made in the law governing the publication of the annual report of the experiment station. Up to the beginning of last year the law provided, briefly: for the publication of the report in two parts, — technical and general, — designated respectively as Part III. and Part IV. of the annual report of the college. The law

provided for the printing by the State of 20,000 copies of Part III. (technical), of which 15,000 copies were to be bound with the report of the State Board of Agriculture, and for the printing of 16,000 copies of Part IV. (the general or popular part of the report), all of which were for the use of the trustees and were distributed by the station.

Besides the annual report of the station in two parts (which was printed by the State) the station published a series of bulletins, the cost of publication being covered by the use of general station funds.

The amended law, in so far as it relates to station publications, is as follows: —

SECTION 1. The annual report of the trustees of the Massachusetts agricultural college may be printed in four parts, namely, . . . part three to consist of the report of the director of the Massachusetts agricultural experiment station and other officers, and part four to consist of the detailed reports of the experiment station.

SECTION 2. . . . ; of part three there may be printed as many copies, not exceeding twenty thousand, as may be requested by the director of the experiment station for the use of said trustees; and of part four, which may be offered for publication in instalments to be known as bulletins, there may be printed as many copies of each instalment as shall be requested by the said director, but in no case to exceed twenty thousand copies, for the use of the said trustees; and in addition there may be printed for the use of the state board of agriculture as many copies of each instalment, not exceeding twenty-five hundred, as may be requested by the said board.

The law as it now stands brings the method of publication into conformity with that recommended by the Association of American Agricultural Colleges and Experiment Stations, and at the same time the new method secures a number of other important advantages: —

1. Results are published promptly in bulletin form instead of being held until the end of the year.

2. The size of the edition of each bulletin and report can be fixed by the director, and can, therefore, be much more closely adapted to the need than under the old law, which definitely specified the number. Under the new law editions have varied from 2,900 to 20,000.

3. As each bulletin is bound by itself it can be circulated with greater economy, being sent only to those specially interested in the subject-matter.

4. The new method avoids sending reports and bulletins in duplicate to individuals whose names are included in the mailing lists both of the station and the State Board of Agriculture, as must frequently have been done under the old law.

5. Under the new law the cost of publication of bulletins is borne by the State, instead of being provided for from the general funds of the station.

6. While securing all these advantages and relieving the station funds, as indicated under paragraph 5, the cost to the State is materially lessened under the new plan of publication. The cost to the State of the station publications during the first year under the new law was rather over $900 less than during the last year under the old law; while during the same period the saving to the station due to the printing of bulletins at State instead of station expense was more than $700.

The following is a complete list of the station publications for the fiscal year just ended: —

Annual Report.

Twenty-sixth annual report: Part I., 65 pages; Part II. (Bulletins Nos. 148–155), 190 pages; Combined Contents and Index, Parts I. and II., 10 pages.

Bulletins.

No. 147. Inspection of Commercial Fertilizers, by H. D. Haskins, L. S. Walker, C. P. Jones and W. S. Frost; 96 pages.
No. 148. On the Diagnosis of Infection with Bacterium Pullorum in the Domestic Fowl, by Geo. Edward Gage; 20 pages.
No. 149. A Study of Variation in Apples, by J. K. Shaw; 16 pages.
No. 150. Reports on Experimental Work in Connection with Cranberries, by H. J. Franklin and F. W. Morse; 32 pages.
No. 151. The Determination of Acetyl Number, by Edw. B. Holland; 10 pages.
No. 152. The Digestibility of Cattle Foods, by J. B. Lindsey and P. H. Smith; 42 pages.
No. 153. A Summary of Meteorological Records, by J. E. Ostrander; 26 pages.
No. 154. Alfalfa, by Wm. P. Brooks; 25 pages.

No. 155. Composition and Use of Some of the New Fertilizer Materials; also Fertilizing Value of Some Local By-Products, by H. D. Haskins; and Cocoanut Meal, by J. B. Lindsey; 18 pages.

Control Series Bulletin No. 1. Inspection of Commercial Feed Stuffs, by P. H. Smith and C. L. Beals; 61 pages.

Circulars.

No. 36. Poultry Manures, their Treatment and Use, by Wm. P. Brooks; revision of No. 35; 4 pages.

No. 37. Green Manuring and Cover Crops, by Wm. P. Brooks; 6 pages.

No. 38. Cabbage, Cauliflower, Turnip, Rape and Other Crucifers, by Wm. P. Brooks; 4 pages.

No. 39. Lime and Sulfur Solutions, by G. E. Stone; 4 pages.

No. 40. Downy Mildew of Cucumbers, by G. E. Stone; 2 pages.

No. 41. The Control of Onion Smut, by G. E. Stone; 4 pages.

No. 42. Fertilizers for Potatoes, by Wm. P. Brooks; revision of No. 26; 4 pages.

No. 43. Cutworms, by H. T. Fernald; revision of No. 2; 2 pages.

No. 44. Suggestions for Judging the Agricultural Value and Adaptation of Land, by Wm. P. Brooks; 8 pages.

No. 45. The Chemical Analysis of Soils, by Wm. P. Brooks; revision of No. 29; 4 pages.

No. 46. Directions for sending Fruits for Identification, by J. K. Shaw; 4 pages.

Reprint State Board of Agriculture Publications.

The Care, Feeds and Feeding of the Dairy Cow, by J. B. Lindsey; 30 pages.

Apple Diseases, by G. E. Stone; 19 pages.

Connecticut Agricultural Experiment Station.

Bulletin No. 180. Studies on the Tobacco Crop of Connecticut, by E. H. Jenkins; 65 pages.

Meteorological Reports.

Twelve numbers, 4 pages each.

The total number of copies of reports and bulletins issued during the last fiscal year was 97,400. In addition, 5,400 meteorological bulletins were printed and 19,500 copies of circulars, making a grand total of 122,300 copies of publications issued during the year.

Publications Available for Distribution.

Bulletins.

No. 33. Glossary of Fodder Terms.
No. 76. The Imported Elm-Leaf Beetle.
No. 115. Cranberry Insects.
No. 130. Meteorological Summary, Twenty Years (1889–1908).
Nos. 131, 135, 140. Inspection of Commercial Fertilizers, 1909–11.
Nos. 132, 136, 139, 142. Inspection of Commercial Feed Stuffs, 1910–12.
No. 133. Green Crops for Summer Soiling.
No. 134. The Hay Crop.
No. 144. The Relation of Light to Greenhouse Culture.
No. 148. On the Diagnosis of Infection with Bacterium Pullorum in the Domestic Fowl. (Technical.)
No. 150. Reports on Experimental Work in Connection with Cranberries.
No. 153. Summary of Meteorological Records, Twenty-five Years (1889–1913).
No. 154. Alfalfa.
No. 156. Electrical Injuries to Trees.[1]
No. 157. The Marguerite Fly.[1]
No. 158. The Nutritive Value of Certain Feeds.[1]
No. 159. The Technical Description of Apples.[1] (Technical.)
No. 160. Report of Cranberry Substation.
No. 161. The Effect on a Crop of Clover of Liming the Soil and Toxic Effect of Iron and Aluminum Salts on Clover Seedlings.
No. 162. Phosphates in Massachusetts Agriculture; Importance, Selection and Use.
Control Series, No. 1. Inspection of Commercial Feed Stuffs, 1914.
Control Series, No. 2. Inspection of Commercial Fertilizers, 1914.[1]
Separata. Composition and Digestibility of Fodder Articles.
Index to bulletins and reports previous to June, 1895 (Hatch Experiment Station).
Index to bulletins and reports, 1888 to 1907 (Hatch Experiment Station).
Index to bulletins and reports, 1883 to 1894 (State Agricultural Experiment Station).
Connecticut Experiment Station Bulletin No. 180. Studies on the Tobacco Crop of Connecticut, by E. H. Jenkins.

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[1] Bulletins Nos. 156 to 162 and Control Series No. 2 were not printed until after the end of the year covered by this report, but are here included as the date of printing the report is later than the dates of printing these bulletins.

Circulars.

No. 20. Lime in Massachusetts Agriculture.
No. 27. Seeding Mowings.
No. 42. Fertilizers for Potatoes.
No. 43. Cutworms.
No. 44. Suggestions for Judging the Agricultural Value and Adaptation of Land.
No. 45. The Chemical Analysis of Soils.
No. 46. Directions for sending Fruits for Identification.
No. 47. The Feeding Value of Apple Pomace.[1]
No. 48. Beet Residues for Farm Stock.[1]
No. 49. Cabbage, Cauliflower, Turnip, Rape, and Other Crucifers.[1]
No. 50. Rations for Dairy Stock.[1]
No. 51. Downy Mildew of Cucumbers.[1]
No. 52. The Control of Onion Smut.[1]
No. 53. Lime and Sulfur Solutions.[1]
No. 54. Poultry Manures, their Treatment and Use.[1]

Annual Reports.

Hatch Experiment Station: Tenth (1898) to seventeenth (1905), inclusive.

Massachusetts Agricultural Experiment Station: Twentieth (1908); Twenty-first, Part II. (1909); Twenty-second, Part I. (1910); Twenty-third, Part I. (1911); Twenty-fourth, Parts I. and II. (1912); Twenty-fifth, Part I. (1913); Twenty-sixth, Part I. and Complete (1913).

The general plan followed in the distribution of our publications has been the same as for several years. The total number of publications sent out to our different mailing lists was 81,735. In addition a very large number of publications was sent in answer to written requests. The extent of the demand is in part indicated by the number of requests — 1,411 — received during the two months, January and February, 1914. The total number of such requests during the year was rather over 5,000.

[1] Circulars Nos. 47 to 54 were not printed until after the end of the year covered by this report, but are here included as the date of printing the report is later than the dates of printing these circulars.

Mailing Lists.

The mailing lists which we maintain and the numbers in the several lists are shown in the following table: —

Residents of Massachusetts (general),	12,136
Residents of other States (general),	918
Residents of other States (general and technical),	1,082
Residents of foreign countries,	157
Newspapers,	525
Libraries,	383
Exchanges,	201
Cranberry growers,	1,728
Beekeepers,	4,450
Feed and fertilizer dealers and manufacturers,	645
Greenhouse vegetable growers,	1,848
Massachusetts florists,	1,100
Miscellaneous special lists,	589
United States Department of Agriculture, official list,[1]	2,275
Meteorological,	395
Total,	28,432

During the year there has been a total increase of rather over 1,800 addresses, — about 7 per cent. At the same time, however, there has been a decrease in the number on our general Massachusetts list. This is accounted for by the increase in special lists. The policy of specialization enables us to effect considerable economy in the circulation of our various publications, for reasons which must be apparent.

Needs of the Station.

In my last annual report particular attention was called to two needs which were discussed and urged at some length, — additional land for use in experiment and provision for experimental demonstrations in various parts of the State. Neither of these needs has been met, and in addition to referring once more to these which are even more urgent now, I must call at-

[1] Publications are not as a rule sent to all on this list, but only to presidents, directors libraries and specialists likely to be interested.

tention to another, — the provision of funds for work in the interest of our market gardeners.

The considerations which lead me to the conclusion that provision for all these needs should be made at as early a day as possible must of course be fully stated and supported before the committees of the Legislature. Some of the more important only, therefore, will be here stated, and that in the briefest possible form.

Additional Land. — New scientific discoveries are constantly broadening our horizon. Every research undertaken usually opens up new vistas and suggests new lines of inquiry. These cannot be undertaken within the limits of the area at present available for experimental use.

The attitude of the public toward the experiment station changes constantly in the direction of looking to it for information upon a constantly increasing number of questions, — questions which cannot be answered in the light of present knowledge and whose solution cannot be undertaken without additional land.

The poultry department of the experiment station finds itself confined to an area which renders satisfactory prosecution of inquiries already in progress quite impossible on account of the extreme difficulty — not to say impossibility — of maintaining a satisfactory degree of health and vigor in the stock without more land upon which the growing birds can range freely.

The considerations stated make it apparent that as the months and years have passed we must have felt and we do now most emphatically feel the need of more land; but not only has there been no increase in the area available for our work, there has been encroachment upon the limited area available made necessary by the growth of the institution. During the past year one line of experiments has been perforce entirely given up, while another has been much reduced in value by the loss of a portion of the plots involved. In each case this interference with our work has been made necessary by the location of new buildings.

In a few of the most urgent cases temporary provision for our needs has been made by leasing tracts of land. The station now

leases five such tracts. This policy of leasing, as pointed out in my last report, is unsatisfactory: —

(*a*) Because it cannot be economically justified since the amount paid for the use of land in most cases is greater than would have been the interest at such rates as the State pays on the cost.

(*b*) On account of the fact that interruption of important lines of work because of termination of leases must in some cases be anticipated.

(*c*) Because the prices which must be paid for land suitably located tend constantly to increase. Purchase can be made now on more favorable terms than can be anticipated later.

The station is at present leasing more than thirty acres, and it is, by courtesy of the owners, using considerable additional land. If we look ahead no longer than I believe to be sound common sense I conclude that something like $40,000 should be made available in the near future for the purchase of land.

Experimental Demonstrations. — New crops and varieties of crops already cultivated among us need testing under varying local conditions as affecting soil and climate, both of which in this State vary widely. This work cannot possibly be done here. Further, conclusions based upon results of experiments here affecting the use of manures, fertilizers and lime, methods of cultivation, etc., need testing in different parts of the State, not only because of variations in soil and climate, but because of variations also in local economic conditions.

Provision should be made for work of this kind, for which purpose I estimate that $1,000 per year should be provided at as early a date as possible.

Work in the Interests of Market Gardeners. — As is well understood, the market-garden industry in this State is very prominent. It is one of the most important branches of our agriculture. The men engaged in the business have long urged that provision should be made for experimental work in their interest. Something can be done, and has been done, on the station grounds but the limitations of the area available restrict the possibilities; moreover, Amherst does not lie in a market-garden section; its soils are not typical of market-garden soils.

There appears to be a feeling among market gardeners, who point to the analogy of the action of the State in the interests of cranberry growers, that the State should make special provision for the establishment of a substation to be devoted to their interests. Numerous important reasons may be urged in favor of such action and doubtless it should ultimately be taken. I believe, however, that for the present the needs of the market gardeners can be fairly met if funds be appropriated for the employment of a suitable man who shall spend his time, during the period of active operations at least, on the market gardens in different parts of the State. Our market gardeners are among the most intelligent and progressive of our farmers. They understand the practical details of their business and apply to them a very high degree of intelligence. They do not particularly need assistance along these lines. The troubles which they experience and those in which they need the assistance of the experiment station are in my judgment for the most part connected with abnormal or disease conditions affecting their crops. They most need the assistance of a plant physiologist and mycologist, — a man able to diagnose plant diseases, to determine whether they are physiological or mycological in origin and who can advise on the proper course to be pursued. Such a man will undoubtedly in many cases discover diseases not yet fully understood.

If the policy of a substation be adopted it will be necessary to provide an expensive laboratory and equipment; for pathological, mycological and bacteriological work are impossible without. Such a laboratory and equipment we now have at the station in Amherst; and a suitable man working among the market gardeners would be able to collect and send material for investigation to this laboratory, where specialists already employed would be able to give it prompt attention.

This traveling expert would also be able to study and make records of the local conditions. He should of course be a good man — a man of considerable experience as well as careful training. A man, however, might be found thoroughly qualified for work of the kind under discussion at a lower salary than would be needed for a man fitted to carry on laboratory investi-

gations. This policy of providing for a traveling expert who should spend his time among the market gardeners in the different parts of the State would, I believe, fairly meet the present need, and may be urged, to restate the principal considerations more briefly, for the following reasons: —

1. He would study conditions locally in the various parts of the State where his services seemed to be needed.

2. If such a man be employed the more purely scientific work connected with the investigation of diseases can be carried on at the station without material increase in the present equipment and by the experts now working at the station.

I would, therefore, strongly urge provision for the employment of a traveling expert, believing that with such an expert the immediate pressing needs of the market gardeners may be fairly met, thus rendering the much larger appropriation which would be essential for the establishment of a substation completely equipped for all lines of work for the present unnecessary. I estimate that for the employment of such a man as is suggested, and to meet the necessary traveling and other expenses, an appropriation of about $2,500 per year will be required.

Private Work.

The attitude of the experiment station relative to undertaking private work for individuals, especially chemical analysis, for which most of the requests for such work come, was fully stated in the twenty-sixth annual report. It seems necessary at this time, however, to once more emphasize the fact that the experiment station is organized and supported for work in the interest of the public. It is contrary to its general policy to undertake work for individuals which has no general or public interest. For the few exceptions the reader is referred to the twenty-sixth annual report.

I desire, however, once more to call particular attention to the fact that there is much misapprehension among owners and operators of land as to the probable value to them of a chemical analysis of their soils. Such analysis does not clearly indicate the crop adaptation nor the manurial or fertilizer needs. These are determined more largely by the structure and the consequent

physical characteristics of the soil than by variations in the chemical composition. In spite of the frequency with which these facts have been pointed out the station still receives a very large number of samples of soil with requests for analysis. Those interested in learning what soils are suited for and their probable value are urged to write for a circular which discusses methods of determining these important points by examination on the spot, — methods which can easily be carried out by any intelligent and careful observer.

In all cases where a study of the conditions and the soil in accordance with the directions of the circular (No. 44) referred to leads to the conclusion that the soil is sour the station will determine the degree of acidity provided a sample taken in accordance with its directions is forwarded for the purpose.

CONTROL WORK.

There has been no change during the past year in any of the laws relative to the control work with which the station is charged. The following table shows the number of official samples taken in each of the years 1909 to 1914, inclusive: —

Number of Official Samples.

Year.	Fertilizers.		Feeds.	
	Brands.	Samples.	Brands.	Samples.
1909,	458	1,052	196	895
1910,	487	890	195	946
1911,	519	1,063	204	1,055
1912,	527	1,180	194	902
1913,	571	1,299	227	1,115
1914,	606	1,307	1,002	924

The shortage and consequent high price of potash salts due to the European war will undoubtedly reduce the number of brands of fertilizers offered in our markets, and will also, without doubt, lead to a reduction in the percentage of potash in many of these brands.

Attention is called to the fact that the station has no authority to require any definite percentage of any plant-food element.

The composition of every fertilizer is entirely at the discretion of the maker. The law requires simply that the dealer state and guarantee the composition.

LINES OF INVESTIGATION.

Most of the lines of investigation, both of the more general and of the more purely research character, referred to in recent reports are still continued. There have been minor modifications in a number of lines, made desirable by the progress of the inquiry. These changes have in some cases rendered desirable a restatement for the director of the office of experiment stations in the case of investigations coming under the Adams fund. No enumeration of the lines of investigation, either general or research, seems necessary at this time for reasons which the statements already made must make apparent.

THE ASPARAGUS SUBSTATION, CONCORD.

No changes requiring mention have occurred in the general management of the substation for investigations connected with asparagus. Mr. Prescott has efficiently looked after the details of cultivation and the determination of the yields under the varying fertilizer treatments, while Mr. Norton of the department of agriculture, as heretofore, has had charge of the breeding work.

There was very little rust in 1913 and the same is true of the year 1914. This fact, while somewhat unfavorable from the standpoint of Mr. Norton, whose object is the production of rust-resistant varieties, was decidedly favorable to obtaining a true measure of the effects and value of the different fertilizer combinations. The crop of 1914 was much the largest so far obtained, and on several of the best plots was at the rate of about 8,000 pounds per acre.

Plant-food Requirements.

The results obtained in 1914 are in very close agreement with those obtained in 1913; and as they were quite fully stated in the twenty-sixth annual report, it seems unnecessary to make a

restatement at this time. A full discussion of the subject is reserved for a final presentation, which will include a full account of the plan of the experiments and of the results throughout the entire period.

THE CRANBERRY SUBSTATION, WAREHAM.

Bulletin No. 160, Part II., page 91, which is a part of this annual report, gives a full account of the experimental work with cranberries during the past year.

The crop produced upon the bog in 1914 was much smaller than in 1913, which should perhaps have been anticipated, since cranberries, like many varieties of apples, show a marked tendency towards much heavier bearing every alternate year.

The following tables will be of interest as they show separately the full expenditure in the commercial management of the cranberry bog and the expenditure immediately connected with the experimental work. Neither statement includes any allowance on account of the salary of Dr. Franklin, who is in local charge.

The tables show also the gross proceeds for the year, amounting to $2,529.36, as against $6,686.87 the previous year. Not only was the crop comparatively small last year, — prices were low as well, which accounts for an abnormally low return.

Bog Account.

Maintenance: —		
Tools or similar equipment bought or repaired,	$116 15	
Oil for engine, etc. (gasoline, kerosene and lubricating),	97 36	
Engine and bog pump repairs,	191 85	
Pumping labor,	97 50	
Bees, rental of,	6 00	
Mowing of upland,	57 25	
Weeding,	31 32	
Fertilizing,	4 22	
Digging out ditches,	61 36	
Repairs to buildings,	12 10	
Lumber and hardware,	59 59	
Raking of vines after picking,	71 63	
Amount carried forward		$806 33

Amount brought forward		$806 33
Maintenance — *Concluded.*		
Resanding bogs,	54 33	
General teaming,	15 37	
Sundries,	19 42	
Miscellaneous labor,	47 33	
		$942 78
Harvesting: —		
Picking,	$544 16	
Separating,	25 00	
Screening,	71 97	
Packing,	10 37	
Carting berries,	50 99	
Coopering,	14 91	
Packing materials,	67 20	
		784 60
Improvements: —		
Blowing out stumps (labor and dynamite),	$93 47	
Building roads,	70 80	
Teaming,	10 42	
		174 69
Total,		$1,902 07

Experimental Account.

Experimental: —		
Labor,	$350 85	
Supplies and apparatus,	245 65	
Chemicals (including insecticides),	20 65	
		$617 15
Stationery and postage,		34 82
Traveling expenses,		136 65
Rental of dry bog,		100 00
Stenographer,		37 30
Contingent: —		
Freight,	$1 09	
Express,	19 82	
Surveying,	5 00	
Telephone,	28 16	
Furnishings,	4 00	
Incidentals,	70	
		58 77
Total,		$984 69

The total sales for the year were as follows: —

Fruit,	$2,511 86
Vines,	17 50
	$2,529 36

The experimental work of the year has followed the general lines mentioned in recent reports.

Weather observations in co-operation with the United States Weather Bureau have been continued, and as a consequence of the records made in connection with these observations and close study of the incidence of frost in different parts of the cranberry district Dr. Franklin feels increasing confidence in his ability to forecast frosts.

A preliminary trial of second-hand shade cloth (used one year by tobacco growers) for covering the vines for protection from frost indicates that this method will prove of value in the case of bogs without water for flooding.

The results obtained in the spraying experiments, carried out in co-operation with the United States Department of Agriculture under the immediate direction of Dr. Shear of the department, have given results somewhat at variance with those obtained in earlier years, and on the whole they do not clearly indicate such methods of spraying as have been tried to be distinctly beneficial. Dr. Franklin has noticed what seems to him a rather serious harmful influence upon the development of the roots of the vines to follow spraying.

As a result of Dr. Franklin's continued careful observations and experiments he has been able to advise in greater detail and with more confidence methods of management which will tend to prevent or greatly reduce the amount of insect damage to the vines and fruit.

Dr. Franklin has discovered that one of the Chalcidids is parasitic upon the eggs of the fruit worm, which is, everything considered, probably the most serious insect enemy of cranberry growers. There appears to be no doubt that this is the most important parasite of any injurious cranberry insect thus far discovered, and Dr. Franklin is now studying the question

whether artificial methods of increasing the effectiveness of this parasite can be discovered.

The fertilizer experiments have been continued, and this year with distinctly favorable results following the application of the fertilizers, especially that of the nitrate of soda. The increases in yield appear to be due to an increase in the proportion of blossoms which set rather than to an increase in size of the berries. Storage tests indicate a slightly impaired keeping quality in the product from fertilized plots. Whether, however, this is connected with a greater percentage of decay or to a greater proportion of loss of water from the more succulent fruit has not been determined.

INVESTIGATION.

The department reports which follow present a general description of the principal experimental work in each, and to these reports reference should be made for detailed information.

Agricultural Department.

The agricultural department has published one bulletin, No. 162, "Phosphates in Massachusetts Agriculture." This will be found in Part II. of this report. The results presented in this bulletin indicate clearly that dissolved rather than natural rock phosphates should generally be employed in Massachusetts agriculture.

The experiments for comparison of different materials as sources of nitrogen used with and without lime indicate a very marked difference in relative effectiveness, especially of the sulfate of ammonia, which without lime does not increase such crops as clover, while with lime it compares favorably with any of the other nitrogen materials. With nitrate of soda, on the other hand, the growth of clover on the unlimed portion of the plots appears to be substantially as good as on the portion of the plots which has been heavily limed. These differences, as will be readily understood, are due in the case of the sulfate of ammonia to the residual acid left in the soil, and in the case of the nitrate of soda to the residual alkali, which renders the use of lime comparatively unnecessary.

The continued comparison of muriate and high-grade sulfate of potash used in connection with bone meal has shown the usual characteristic differences, resulting in a very marked superiority of yield of raspberries, blackberries and rhubarb on the sulfate and of asparagus on the muriate.

The experiments to determine the relative value of all the available potash salts and feldspar as sources of potash indicate a considerable superiority of the sulfate as compared with kainit, that feldspar seems to be absolutely unavailable, and that nitrate and carbonate are valuable sources of potash, the crop for the year being potatoes.

The comparison of different phosphates indicates: —

1. That the dissolved phosphates greatly promote rapid growth in the early stages of development, and that the different forms of bone meal are also fairly favorable to such growth; that slag meal is much superior to rock phosphates, the latter showing but little superiority to the no-phosphate plots.

2. The percentage of soft corn is affected, as might be anticipated from the statements just made, being highest on the no-phosphate plots, followed closely by the rock phosphates, and least on the dissolved phosphates.

3. Dissolved phosphates, the bone meals and slag give a larger average increase in crop than the rock phosphates.

In the soil tests, both north and south, the fact that potash is the dominant plant-food requirement for soy beans and clover is again shown.

The top-dressing experiments with permanent mowings have shown lower returns than usual, apparently because the weather conditions at the critical period have been highly unfavorable to clover, which was almost entirely absent during the past year from fields so top-dressed that it is usually abundant.

The Chemical Department.

The chemical department, besides publishing two bulletins in the control series, one on fertilizers, the other on feeds, has published two others: No. 158, discussing the nutritive value of certain feeds, and No. 161, "The Effect on a Crop of Clover

of Liming the Soil and Toxic Effect of Iron and Aluminum Salts on Clover Seedlings."

The results presented in Bulletin No. 158 indicate among other things that molassine meal possesses about three-fourths the feeding value of corn meal; that it does not increase, but rather tends to decrease digestibility of coarse feeds fed in connection with it. It, however, seems to serve as an appetizer and in some cases increases palatability of coarse feeds, and is recommended for horses, as it seems to render attacks of colic less probable.

The bulletin shows that the quality of cottonseed meal and hulls seems to grow poorer from year to year. The percentage of hulls shows a tendency to increase and the more abundant these are the lower the feeding value. The results presented indicate that cottonseed feed meal possesses only about one-half the feeding value of good cottonseed meal, while it sells at about three-fourths of the price of the latter.

Cocoa shells are believed to possess about one-half the feeding value of corn meal.

Wheat or grain screenings, if finely ground, may constitute a useful feed, and the better samples have approximately the feeding value of wheat bran. Such feeds exhibit wide variations.

Flax shives are not believed to be worth the attention of eastern feeders.

Mellen's food refuse will, it is believed, prove desirable if it can be purchased at about three-fourths the cost of wheat bran.

The results presented indicate that CXX feed is a quite inferior product.

Professor Morse shows in Bulletin No. 161 a great increase in the size of clover plants and in the percentage of nitrogen in them, both on the no-nitrogen plots and on plots supplied with nitrogen in the form of sulfate of ammonia, following a heavy application of lime. To a lesser degree similar differences are shown where other nitrogen materials are applied. These differences, in the opinion of Professor Morse, are produced rather by the action of the lime on the properties of the soil than by its action within the plant itself.

Mr. Ruprecht shows that aluminum sulfate in culture solutions has a very toxic action on clover seedlings if present in quantity greater than forty parts per million, and that ferrous sulfate if present in concentration above four parts per million exerts a somewhat similar effect. He shows further that this toxic effect can be overcome in large measure in dilute solution by the use of calcium carbonate.

His experiments appear to indicate that one of the principal reasons for the failure of clover on plots fertilized with sulfate of ammonia without lime is due to the fact that aluminum and iron are to some extent brought into solution by the action of the sulfuric acid of the ammonium sulfate.

The report of the chemist calls attention to a number of improvements in chemical methods, especially in methods connected with the examination of fats, which have been perfected by Mr. Holland and Mr. Buckley. It makes brief reference to the investigations of Professor Morse on the chemical composition of asparagus, and briefly presents the principal results of some investigations in animal nutrition.

It has been shown that vegetable ivory, in spite of its hard and horny nature, appears to be to a considerable extent digestible, and may be a food product of some value.

The report gives the usual account of the results of the inspections of commercial fertilizers and food stuffs and the examination of Babcock glassware.

The Botanical Department.

The botanical department has published one bulletin during the year, No. 156, "Electrical Injuries to Trees." This bulletin gives important information on the following points: the electrical resistance in trees; the effects of alternating and of direct currents; the effects of lightning and earth discharges; and discusses methods of preventing injury from contact with wires carrying electric currents.

The report of the botanist calls attention to some of the plant diseases which have been unusually common during the past year. Among these the Rhizoctonia disease of potatoes is one of the most serious.

The report points out that chestnut blight is spreading, but expresses the opinion that the disease is held somewhat in check by natural causes, probably climatic.

Attention is called to a number of diseases, new (so far as known) in this State, the seriousness of which is not at present understood.

The Entomological Department.

The entomological department has published one bulletin during the year, No. 157, "The Marguerite Fly." This bulletin gives an account of the life history and habits of this highly injurious insect, and discusses methods of control of this serious greenhouse pest. The author recommends spraying with nicotine solutions. "Black Leaf 40," diluted with 400 to 450 parts of water applied at intervals of about twelve days (or oftener if the temperature of the greenhouse is unusually high) has proved effective with Marguerites.

The Horticultural Department.

The horticultural department has published one bulletin during the year, No. 159, "The Technical Description of Apples." This bulletin calls attention to variety characters which the writer believes will prove of much value in determining varieties in the absence of specimens of fruit. The methods of determination proposed are based in considerable measure upon leaf characters, and the bulletin should prove a valuable contribution to this important subject.

The report of the horticulturist, especially that part of it contributed by Dr. Shaw, calls attention to the progress of investigations on the effect of the stock on the scion. Unanticipated difficulties have been experienced in getting certain varieties established upon their own roots, but such a degree of progress is recorded as will make possible the planting of a considerable proportion of the area available with trees on known roots the coming spring.

The Veterinary Department.

The investigational work of the veterinary department has been directed chiefly toward the development of methods for the diagnosis of bacillary white diarrhœa in adult fowls and the prevention of hog cholera by the use of anti-hog cholera serum.

During the past year the method recommended in Bulletin No. 148 has been put to practical test. It has been found possible to detect individuals harboring *Bacterium pullorum*, thus making possible the elimination of such individuals from breeding flocks. Of one thousand chickens hatched from eggs from tested hens in one flock not one died of white diarrhœa, while during the previous season, before the bearers of infection had been eliminated from the flock, only two hundred chicks of two thousand hatched survived the ravages of the disease.

The reports of the treasurer and of the different departments immediately follow the director's report. The bulletins to which reference has been made will be found in Part II. of the annual report.

WM. P. BROOKS,
Director.

REPORT OF THE TREASURER.

ANNUAL REPORT

Of Fred C. Kenney, Treasurer of the Massachusetts Agricultural Experiment Station of the Massachusetts Agricultural College, for the Year ending June 30, 1914.

United States Appropriations, 1913–14.

	Hatch Fund.	Adams Fund.
Dr.		
To receipts from Treasurer of the United States, as per appropriations for fiscal year ended June 30, 1914, under acts of Congress approved March 2, 1887 (Hatch fund), and March 16, 1906 (Adams fund), . . .	$15,000 00	$15,000 00
Cr.		
By salaries, ...	$12,099 49	$13,047 20
labor, ...	1,280 80	901 01
publications, ...	704 34	–
postage and stationery, ...	13 33	26 38
freight and express, ...	–	13 26
heat, light, water and power, . . .	8 63	–
chemicals and laboratory supplies, . .	39 78	132 57
seeds, plants and sundry supplies, . .	119 72	292 55
fertilizers, ...	675 16	241 12
feeding stuffs, ...	–	–
library, ...	30 92	22 57
tools, machinery and appliances, . . .	20 43	–
furniture and fixtures, ...	–	29 04
scientific apparatus and specimens, . .	–	153 87
live stock, ...	7 40	–
traveling expenses, ...	–	70 44
contingent expenses, ...	–	–
buildings and land, ...	–	69 99
Total, ...	$15,000 00	$15,000 00

State Appropriations, 1913–14.

Cash balance brought forward from last fiscal year,	$11,574 55
Cash received from State Treasurer,	23,500 00
fertilizer fees,	11,244 00
farm products,	9,061 91
miscellaneous sources,	9,631 40
	$65,011 86
Cash paid for salaries,	$19,965 04
labor,	13,944 65
publications,	1,999 82
postage and stationery,	1,380 09
freight and express,	544 29
heat, light, water and power,	375 93
chemicals and laboratory supplies,	1,307 46
seeds, plants and sundry supplies,	1,536 36
fertilizers,	201 40
feeding stuffs,	1,690 22
library,	507 27
tools, machinery and appliances,	538 96
furniture and fixtures,	880 97
scientific apparatus and specimens,	931 45
live stock,	80 10
traveling expenses,	3,326 12
contingent expenses,	802 67
buildings and land,	1,105 68
miscellaneous,	96 30
balance,	13,797 08
Total,	$65,011 86

REPORT OF THE ASSISTANT AGRICULTURIST.

E. F. GASKILL.

The experimental work in the agricultural department during the past year has followed the same general lines of investigation as in previous years. Most of the experiments in this department have dealt with some phases of the question of soil fertility. Such work to be of value must be conducted over a long period of years; and some of the fertilizer experiments started by the late Dr. Goessmann are continued with minor modifications. The work this year has involved the use of 189 plots, 13 orchard plots, 4 pasture plots and 147 closed plots. The latter are used to check results obtained in the field.

The results obtained from year to year have been published in annual reports of the station, but it is hoped in the near future to bring all of this information for each experiment together in bulletin form.

It has not been the custom to report the work in detail each year, therefore only a few of what seem to be the more striking results will be presented.

Field A, or the Nitrogen Experiment.

This experiment was begun in 1890 and is a study of the relative value as sources of nitrogen of barnyard manure, nitrate of soda, sulfate of ammonia and dried blood.

In 1913 the west half of each plot received an application of hydrated lime at the rate of 2 tons per acre.

This year the field was seeded on May 16 with a mixture of timothy, red-top and clover. Oats (1 bushel per acre) were sown as a nurse crop. The oats were cut July 23 and made into hay. The average yield for this year on the different nitrogen and no-nitrogen plots is shown in the following table: —

Average Yields per Acre, 1914 (Oat Hay).

Plots.	Limed (Pounds).	Unlimed (Pounds).	Average (Pounds).
Nitrate of soda, 1 and 2,	4,350	2,700	3,525
Dried blood, 3 and 10,	3,550	2,500	3,025
Sulfate of ammonia, 5, 6 and 8,	3,533	2,167	2,850
No nitrogen, 4, 7 and 9,	2,533	1,433	1,983
Manure, 0,	3,200	2,100	2,650

These figures show that the application of lime increased the yield on each plot.

On the basis of 100 for nitrate of soda, the relative standing of the different nitrogen plots and no-nitrogen plots, as measured by total yield during the past season, was as follows: —

	Oat Hay (Per Cent.).
Nitrate of soda,	100.00
Dried blood,	85.81
Sulfate of ammonia,	80.85
Manure,	75.18
No nitrogen,	56.25

The relative standing of the different materials as indicated by total yield for the twenty-five years during which the experiment has continued is as follows: —

	Per Cent.
Nitrate of soda,	100.00
Manure,	93.53
Dried blood,	93.21
Sulfate of ammonia,	88.38
No nitrogen,	72.35

On the basis of increase as compared with the no-nitrogen plots the relative standing for the different fertilizers for the twenty-five years is as follows: —

	Per Cent.
Nitrate of soda,	100.00
Manure,	76.60
Dried blood,	75.44
Sulfate of ammonia,	57.97

Considering the relative standing of the different nitrogen fertilizers on the basis of yields per acre, nitrate of soda, as in previous years, stands first.

On the basis of increase as compared with the no-nitrogen plots for the entire period of the experiment (twenty-five years) the nitrate of soda also ranks first.

The crop of grass and clover was not cut, but on September 9 the following condition was noted: on the limed area of each plot there was a very luxuriant growth, — practically all clover. There was no apparent difference in the amount of clover on the nitrogen and no-nitrogen plots.

On the unlimed area of all plots, except those receiving nitrate of soda, the stand of clover was much inferior to that on the limed area. The stand of clover on the unlimed area of the plots receiving sulfate of ammonia was much inferior to that on the unlimed areas of any of the other plots. The stand of clover on the limed area of the sulfate of ammonia plots was about as good as that on the limed area of the nitrate of soda and no-nitrogen plots. The unlimed area of the nitrate of soda plots seemed to produce practically as good a stand of clover as the limed areas.

Comparison of Muriate and High-grade Sulfate of Potash (Field B).

The work on this field, where for so many years we have had under comparison the two potash salts, muriate and high-grade sulfate, has been continued. The following table shows the increased yields per acre due to the use of the two potash salts: —

Crop.	Increase due to Use of —		Cash Value of Increase.	Increased Cost of Sulfate.	Increase returns from —	
	Sulfate (Pounds).	Muriate (Pounds).			Sulfate.	Muriate.
Raspberries, ...	1,635	–	$196 20	$1 05	$195 15	–
Blackberries, ...	537	–	34 40	1 05	33 35	–
Rhubarb, ...	4,538	–	90 76	1 05	89 71	–
Asparagus, ...	–	180	18 00	1 05	–	$19 05

In case of the raspberries the sulfate plot produced at the rate of 1,635 pounds per acre more than the muriate. Considering the raspberries worth 15 cents per quart it is seen that the sulfate returned $196.20 more per acre than the muriate.

The two salts are applied on the basis of equal applications of actual potash, which means about 200 pounds per acre of each. Used at these rates the sulfate cost this year about $1.05 more per acre than the muriate.

The sulfate plot also ranks ahead of the muriate plot for the crops of blackberries and rhubarb. The muriate plot, however, ranks ahead in case of the asparagus, having a balance in its favor of $19.05 per acre.

Comparison of Potash Salts (Field G).

In this experiment we have had under comparison for seventeen years seven different materials that may be used as sources of potash. There are 5 check or no-potash plots, and each material furnishing potash is used on 5 different plots, thus making 40 plots in the field. The crop this year was potatoes. The following table gives the average yields per acre on the different potash salts, also the relative standing of each: —

Fertilizer.	Large (Bushels).	Small (Bushels).	Total (Bushels).	Rank, No potash equals 100.
No potash,	122.80	22.80	145.60	100.00
Kainit,	129.40	15.23	144.63	99.33
High-grade sulfate of potash,	173.53	15.97	189.50	130.15
Low-grade sulfate of potash,	159.70	15.90	175.60	120.60
Muriate of potash,	177.40	12.63	190.03	130.52
Nitrate of potash,	190.83	15.20	206.03	141.50
Carbonate of potash,	193.33	20.10	213.43	146.59
Feldspar,	124.13	13.57	137.70	94.57

The small yields obtained are due largely to the fact that the soil is badly infested with the potato scab fungus.

Potatoes were grown this year for the purpose of studying, in co-operation with the department of vegetable pathology, the control of this fungus. The experiment will be repeated another year.

Comparison of Different Phosphates.

On one of our fields we have had under comparison since 1897 ten different materials that are used as sources of phosphoric acid. Each plot has received annually a liberal application of nitrogen and potash in highly available forms. The different phosphates are used in such quantities as to supply equal phosphoric acid to each plot. There are 3 check plots which receive no phosphates.

This year a very good crop of rye was plowed under in May. The field received an application of hydrated lime at the rate of 1 ton per acre.

The crop this year was Longfellow corn, planted May 28 and cut and stooked September 26, on which date it was fairly well matured. The following table shows the average height of the plants on the different plots on July 10: —

Plot.	Fertilizer.	Inches.	Plot.	Fertilizer.	Inches.
1, . .	No phosphate, .	32.23	8, . .	Dissolved boneblack,	42.15
2, . .	Arkansas rock, .	28.92	9, . .	Raw bone, . .	40.02
3, . .	South Carolina rock,	30.83	10, . .	Dissolved bone meal,	38.79
4, . .	Florida soft rock, .	32.62	11, . .	Steamed bone, . .	40.20
5, . .	Slag, . . .	35.67	12, . .	Acid phosphate, .	42.05
6, . .	Tennessee rock, .	32.99	13, . .	No phosphate, .	29.69
7, . .	No phosphate, .	30.96			

The above figures make it very apparent which phosphates are the more quickly available.

The following table shows the yield per acre on the different plots: —

Plot.	Fertilizer.	Hard Corn.	Soft Corn.	Stover (Pounds).	Increase over No Phosphate.	
					Hard Corn.	Stover (Pounds).
1,	No phosphate,	74.6	5.0	6,720	–	–
2,	Arkansas rock,	67.6	7.2	7,120	6.3	1,240
3,	South Carolina rock,	75.5	5.0	6,880	14.2	1,000
4,	Florida soft rock,	68.2	7.4	6,920	6.9	1,040
5,	Slag,	70.8	6.0	8,640	9.5	2,760
6,	Tennessee rock,	72.0	6.0	6,640	10.7	760
7,	No phosphate,	66.4	8.4	6,560	–	–
8,	Dissolved boneblack,	80.8	3.4	7,240	19.5	1,360
9,	Raw bone,	82.8	2.8	7,400	21.0	1,520
10,	Dissolved bone meal,	74.5	2.8	7,280	13.2	1,400
11,	Steamed bone,	75.9	4.6	6,920	14.6	1,040
12,	Acid phosphate,	71.8	2.8	6,240	10.5	360
13,	No phosphate,	42.8	9.1	4,360	–	–

Plot.	Fertilizer.	Per Cent. of Hard and Soft Corn.	
		Hard.	Soft.
1,	No phosphate,	93.7	6.3
2,	Arkansas rock,	90.4	9.6
3,	South Carolina rock,	93.8	6.2
4,	Florida soft rock,	90.2	9.8
5,	Slag,	92.2	7.8
6,	Tennessee rock,	92.3	7.7
7,	No phosphate,	88.8	11.2
8,	Dissolved boneblack,	96.0	4.0
9,	Raw bone,	96.7	3.3
10,	Dissolved bone meal,	96.4	3.6
11,	Steamed bone,	94.3	5.7
12,	Acid phosphate,	96.2	3.8
13,	No phosphate,	82.5	17.5

North Corn Acre.

In this experiment we have had under comparison for twenty-five years two fertilizer mixtures, in one of which the percentage of potash is high and that of phosphoric acid low; while in the other (which represents about the average analysis of the commercial corn fertilizers offered on our markets) the percentage

of phosphoric acid is high and that of potash low. For the past nineteen years the rotation has been two years grass and two years corn. This year the field was in grass, and the combination containing the higher percentage of potash gave more hay than the mixture containing the lower percentage of potash. This result is similar to results obtained in previous years, except that owing to the severe drought of the last season we did not harvest a rowen crop.

North Soil Test.

In this experiment there are 13 plots which have received the same fertilizer treatment for twenty-six years. The west half of each plot has received three applications of lime. In 1899 and 1904 lime was applied at the rate of 1 ton per acre and in 1907 at the rate of ½ ton per acre. This year the crop was mixed grass and clover. The following table gives the yields per acre on the different plots: —

Yield per Acre (Pounds).

Plot.	Fertilizer.	Limed.		Unlimed.	
		Hay.	Rowen.	Hay.	Rowen.
1, 4, 8 and 12,[1] . .	No fertilizer, . .	2,242½	220	1,065	–
2, ...	Nitrate of soda, . .	2,870	–	2,020	–
3, ...	Dissolved boneblack, .	1,680	–	1,490	–
5, ...	Muriate of potash, .	4,140	1,400	1,280	–
6, ...	Nitrate of soda, . . Dissolved boneblack, .	3,800	40	2,540	–
7, ...	Nitrate of soda, . . Muriate of potash, . .	3,080	1,000	2,000	–
9, ...	Dissolved boneblack, . Muriate of potash, . .	3,620	800	1,030	–
10, ...	Nitrate of soda, . . Dissolved boneblack, . Muriate of potash, . .	5,310	800	2,600	–
11, ...	Plaster, ...	2,400	200	860	–
13, ...	Nitrate of soda, . . Dried blood, . . . Dissolved boneblack, . Muriate of potash, . .	7,240	1,000	3,000	–

[1] Average.

The rowen crop was unusually light, owing to the deficiency in rainfall. On all of the unlimed plots and on 2 of the limed plots the crop was too small to cut. The rowen crop was practically all clover, and the figures in the table show quite conclusively the necessity of using potash and lime for a leguminous crop.

The continued use of these different materials greatly affects the character of the growth. We find practically no clover on the unlimed halves of the no-fertilizer plots, nor on the unlimed portions of the plots receiving nitrate of soda, dissolved boneblack, nitrate of soda and dissolved boneblack, or plaster, while on all plots where potash is used we find clover, but not as abundantly as on the limed halves of the same plots.

South Soil Test.

On this field each plot has received the same fertilizer treatment for twenty-six years. The crop this year was medium green soy beans, which were injured by an early frost, before the beans matured. The crop was cut soon after the frost, before many of the leaves had fallen off, and made into hay. Following are the yields per acre from some of the plots: —

Plot.	Fertilizer.	Soy Bean Hay (Pounds).
3, 6, and 12,	Nothing,	1,500[1]
1,	Nitrate of soda,	3,500
2,	Dissolved boneblack,	900
4,	Muriate of potash,	6,000
10,	Nitrate of soda, Muriate of potash,	9,100
11,	Dissolved boneblack, Muriate of potash,	7,700
14,	Nitrate of soda, Dissolved boneblack, Muriate of potash,	9,800
5,	Lime,	1,200
13,	Plaster,	1,700
7,	Manure,	11,500

[1] Average of 3 plots.

These results are in accordance with those obtained in previous experiments. The largest crop is obtained on plots where potash is used alone or in combination with other materials.

Grass Plots.

The experiment in top-dressing grass lands with different materials used in rotation has been continued. The yield of hay this year was below the average. The following table gives the yields per acre: —

Plot.	Fertilizer.	Hay (Pounds).	Rowen (Pounds).
1,	Manure,	3,571	1,670
2,	Bone meal, Muriate of potash,	3,698	1,359
3,	Muriate of potash,[1] Basic slag,[1]	3,480	1,405

The average yield to date under the three systems of top-dressing are: —

	Pounds per Acre.
When top-dressed with manure,	6,021
When top-dressed with bone meal and potash,	5,914
When top-dressed with slag and potash,[2]	5,542

The fescue mixture produced this year when top-dressed with manure 331 pounds more of hay per acre than the timothy mixture, and 270 pounds more rowen.

On the plot top-dressed with bone meal and muriate of potash the difference in favor of the fescue mixture was 1,008 pounds hay per acre and 263 pounds rowen.

The results obtained are similar to those obtained for the last few years. During the first few years of the experiment the timothy mixture produced the larger yields, but for the past three or four years the fescue mixture has produced the larger crop.

[1] In place of ashes used in earlier years.

[2] Formerly wood ashes.

Sulfate of Ammonia v. Nitrate of Soda as a Top-dressing for Permanent Mowings.

This field has been continuously in grass since 1899. In 1908 the present plots were laid off, with an idea of studying the relative value of sulfate of ammonia and nitrate of soda as a top-dressing for grass. The materials are used in such quantities as to supply equal nitrogen to each plot. There is a check plot which receives an application of: —

	Pounds per Acre.
Bone meal,	400
Muriate of potash,	180
Basic slag,	400

The sulfate of ammonia and the nitrate plots also receive this mixture. The sulfate of ammonia has been used at the rate of about 175 pounds per acre, and the nitrate of soda at about 233⅓ pounds per acre. The following table shows the increased yield per acre due to the use of the two chemicals for each year since the experiment started: —

Year.	Sulfate of Ammonia.		Nitrate of Soda.	
	Hay (Pounds).	Rowen (Pounds).	Hay (Pounds).	Rowen (Pounds).
1908,	1,030.0	505.0	1,465.0	545.0
1909,	1,892.0	-	1,805.0	-
1910,	870.0	—485.0	1,455.0	—690.0
1911,	1,012.5	—66.5	1,262.5	—60.5
1912,	1,604.0	162.0	1,134.0	130.5
1913,	1,402.5	36.5	1,122.5	18.0
1914,	975.0	86.0	1,133.5	335.5
Averages,	1,255.0	39.7	1,339.6	46.4

From the above table it will be apparent that the nitrate of soda has this year produced the greater increase. This is true in four out of the seven years, and the net excess of the nitrate plot over the sulfate plot for the seven years is 592 pounds per acre.

In case of the rowen there are two years in which neither the sulfate nor the nitrate produced as large a crop as the check plot. For the entire period of the experiment the increase on the nitrate plot is slightly better than that on the sulfate plot.

The following table shows the increase in cost per acre due to the addition of sulfate of ammonia and nitrate of soda to the mixture: —

Year.	Cost per Acre.	
	Sulfate of Ammonia.	Nitrate of Soda.
1908,	6.73	6.66
1909,	6.34	6.02
1910,	6.22	5.73
1911,	6.10	5.68
1912,	6.23	5.92
1913,	6.42	6.62
1914,	6.68	6.29
Averages,	6.39	6.13

From the tables it will be seen that nitrate of soda has produced the larger increase and at a lower cost.

Lime Experiment.

An experiment to study the relative value of different sources of lime on the basis of equal applications of combined calcium and magnesium oxides was begun this year. The field selected for this experiment is the one on which for so many years we studied the effects of spring and winter applications of manure. The plots have not received any manure since 1911.

There were five pairs of plots in the manure experiment, and since there are four different kinds of lime to be tested, one pair of plots is given up to each kind of lime and one pair is used as a check plot, receiving no lime. No manure or fertilizer of any kind was applied this year.

The crop grown was medium green soy beans, which were cut green and put in the silo with corn. The following table gives the yields per acre of hay in 1913 before liming, and of

soy beans (cut green) in 1914 after liming. The second column shows the relative yield on the different plots, that on the no-limed plot being taken as 100: —

Actual and Relative Yields.

Fertilizer.	Before Liming, 1913.		After Liming, 1914.	
	Hay per Acre (Pounds).	No Lime equals 100.	Soy Beans[1] per Acre (Pounds).	No Lime equals 100.
Tobey lime,	5,284	141.7	13,692	148.0
Marl,	5,010	134.0	13,738	148.5
Ground limestone,	4,490	120.0	9,887	106.9
No lime,	3,730	100.0	9,250	100.0
Limoid,	5,100	136.7	10,437	112.8

[1] Cut green.

Attention is called to the fact that this is the first year of the experiment, and results above do not necessarily represent ultimate relative values.

Variety Test Potatoes.

The work of testing different varieties of potatoes has been continued. The seed planted this year was selected from the more promising varieties grown last year. This seed originally came from several different sources; the present season is the third year that the varieties have been grown on our plots.

The plan included two rows of each variety, every seventh row being a check variety. The Green Mountain was planted in the check rows. The following table gives the yield per acre of the five leading varieties: —

Late, 1912.	Bushels.	Early, 1912.	Bushels.
Sutton's Early Monarch,	312	Early Six Weeks,	155
Sir Walter Raleigh,	270	Trust Buster,	116
Clyde,	210	Buckbees Extra Early Rockford,	113
Quick Crop,	198	Early Surprise,	105
Snow,	189	Six Weeks,	102
Green Mountain (average of seven rows).	181		

Late, 1913.	Bushels.	Early, 1913.	Bushels.
Quick Crop,	155	Irish Cobbler,	114
Northern Star,	137	Petoskey,	110
Farmer Potato,	134	Early Surprise,	107
Sir Walter Raleigh,	128	Trust Buster,	104
Clyde,	126	Early Six Weeks,	89
Green Mountain (average of seven rows).	118		

Late, 1914.	Bushels.	Early, 1914.	Bushels.
Farmer Potato,	434	Early Six Weeks,	224
Sir Walter Raleigh,	422	Irish Cobbler,	208
Sutton's Early Monarch,	390	Early Surprise,	206
Quick Crop,	364	Trust Buster,	200
Clyde,	355	Johnson's Flour Ball,	189
Green Mountain (average of seven rows).	334		

In 1913 there was one check row that yielded better than any of the varieties. In 1914 one check row yielded practically the same as the Clyde.

REPORT OF THE CHEMIST.

JOSEPH B. LINDSEY.

1. Work of Investigation.

Mr. Holland and Mr. Buckley have continued their studies on the chemistry of butter fat. A method has been perfected for determining monohydroxy acids and dihydroxy acids and their glycerides. This method was published in detail in Bulletin No. 151 of the station.

A modification of the Hehner and Mitchell method has been made for determining the amount of stearic acid in the insoluble acids of butter fat. The stearic acid is determined by crystallization from a supersaturated solution of alcohol and stearic acid at approximately 0° C. It involves the use of a jacketed tank of ice and water with stirring apparatus, supersedes the earlier method in which alcohol and stearic acid were used without agitation, and yields a much larger amount of stearic acid in case of butter.

A method has been practically completed for the determination of unsaponifiable matter of oils and fats by continuous extraction of the saponified product after drying.

The fifth year of the stability test with olive oil is approaching completion and the results will be brought together for publication within a short time.

The new method for stearic acid is bound to prove very helpful in enabling us to determine, with a greater degree of accuracy, the chemical composition of the insoluble acids of butter fat.

Mr. Morse and Mr. Ruprecht have continued their work in investigating the chemistry of asparagus and the effect of fertilizers in modifying the character of the asparagus plant. The actual fertilizer effect on proportionate composition has been found to be slight, being most marked in case of the nitrogen and potassium contents.

The character of the sugar group is being studied by comparing the specific rotatory power of purified syrups obtained from different parts of the plant at different seasons. The change in rotation indicates a marked change in the character of the sugar groups at different stages of translocation and photosynthesis.

A study of the bog water from the so-called cranberry tiles has been continued. Samples of fruit and vines from groups of fertilized and unfertilized bogs have been preserved for analysis.

Considerable time has been devoted to the study of the effect of sulfate of ammonia in modifying the character of the soil and checking the normal growth of clover.

Drainage waters from sulfate of ammonia plots of Field A have been analyzed and point to the exhaustion of calcium as a base, but do not show any accumulation of sulfuric acid as a free acid. Another application of lime has been made to this field and has shown a very favorable effect on the growth of clover. This investigation is being continued. The problem is a complex one and involves a large amount of work before it can be hoped to secure definite results.

Dr. Lindsey has continued studies in animal nutrition. A large number of digestion experiments with sheep have been made during the year, upon such materials as Molassine Meal, vegetable ivory, pumpkins, carrots and cabbages.

A study of the digestibility of crude fiber in different cattle feeds has been undertaken but no decisive results have as yet been secured.

Two experiments have been completed to study the value of alfalfa as a roughage. It seems probable that a combination of hay, alfalfa and corn stover, together with corn-and-cob meal and a little cottonseed meal, will form a most satisfactory ration for dairy animals. The experiments indicate that it will hardly be advisable to have the coarse part of the ration consist entirely of alfalfa or even of alfalfa and corn stover.

A special study has been made of the nutritive value of vegetable ivory for dairy animals. The results thus far indicate that in spite of its hard, horny nature, animals are able to utilize

this material as a source of nutrition. The material is being further investigated.

The value of New Mineral and Stone Meal fertilizers has been studied and is referred to under a separate heading.

The same remark may be made relative to the availability of organic nitrogen in commercial fertilizers, and of the relative value of basic phosphatic slag as a source of phosphoric acid.

2. Work of the Fertilizer Section.

The principal work of the fertilizer section, in charge of Mr. Haskins with Messrs. Walker, Jones and Frost as assistants, has been the annual inspection of commercial fertilizers. The number of brands registered, collected and analyzed during 1914 is considerably in excess of that in any previous year.

(*a*) *Fertilizers registered.*

During the season of 1914, 110 manufacturers, importers and dealers, including the various branches of the large corporations, have secured certificates for the sale of 564 different brands of fertilizer, agricultural chemicals, raw products and agricultural lime. They may be classed as follows: —

Complete fertilizers,	366
Fertilizers furnishing phosphoric acid and potash,	11
Ground bone, tankage and dry ground fish,	56
Chemicals and organic nitrogen compounds,	98
Agricultural limes,	33
	564

(*b*) *Fertilizers collected and analyzed.*

During 1914, 135 towns were visited, and 1,307 samples, representing 606 distinct brands, which include private mixtures, were drawn from stock found in the possession of 365 different agents and consumers. This represents 8 more samples and 35 more brands than were taken during the previous year.

Seven hundred and eighty-one analyses (603 distinct brands) have been made during the year's inspection. They are as follows: —

Complete fertilizers,	453
Fertilizers furnishing phosphoric acid and potash,	18
Ground bone, tankage and dry ground fish,	79
Nitrogen compounds,	105
Potash compounds,	43
Phosphoric acid compounds,	40
Lime compounds,	43
	781

Full details regarding the fertilizer inspection work will be found in Bulletin No. 2, control series, published in December, 1914.

(*c*) *Other Activities of the Fertilizer Section.*

Up to Dec. 1, 1914, analyses were made as follows: weights and dry matter determinations on 96 samples of millet for the agricultural department; dry matter determinations in connection with the basic slag and stone meal experiment on 13 samples of oats and 8 samples of potatoes; 45 dry matter determinations on corn, cob and stover in this experiment.

In connection with pot experiments to determine the relative nitrogen availability on some suspected samples of commercial fertilizer found in the 1913 fertilizer inspection, 114 dry matter and nitrogen determinations were made. This included weighing the product from each pot. In connection with another series of pot experiments with millet to determine the relative nitrogen availability on samples of fertilizer submitted by the Referee on Nitrogen for the Association of Official Agricultural Chemists, 42 dry matter and nitrogen determinations were made. This work was undertaken in order to compare the actual nitrogen activity of the water insoluble portion of these different nitrogen sources with the laboratory methods (the alkaline and neutral permanganate).

In addition to the above, 408 different substances have been received and analyzed for farmers, farmers' organizations and the various departments of the experiment station, as follows: —

Fertilizers and by-products used as fertilizers,	226
Lime products,	30
Soils for lime requirement test,	100

Soils for complete analysis,	4
Soils for partial analysis,	21
Tobacco soils suffering from over-fertilization, suspected of causing malnutrition of the crop,	14
Greenhouse soils suffering from over-fertilization, suspected of causing malnutrition of the crop,	13

The usual time has been given to co-operative work with the Association of Official Agricultural Chemists, Mr. Walker having served the association in the capacity of associate referee on phosphoric acid and Mr. Haskins as associate referee on nitrogen. In this connection studies have been made on new methods for the determination of the three fertilizer constituents (nitrogen, phosphoric acid and potash) in fertilizers.

(d) *Field Experiments with Basic Slag Phosphate.*

The work begun in 1913 to study the availability of the phosphoric acid in basic slag phosphate, as outlined by the Association of Official Agricultural Chemists, has been continued. The data resulting from this experiment would indicate that the field is not sufficiently depleted in phosphorus to warrant making the final field experiment, and it is probable that the growing of crops on the land another year will be necessary.

(e) *Field Experiments with New Mineral Fertilizer and Stone Meal.*

This experiment, begun in 1912, has been continued. The conclusions drawn from this year's experiment will be found in Bulletin No. 2, control series, published in connection with the results of the fertilizer inspection.

(f) *Other Vegetation Experiments.*

The experiment begun in the greenhouse in the winter of 1914 for the purpose of comparing the nitrogen availability of some suspected brands of fertilizer found in the 1913 fertilizer inspection was completed. Conclusions will be found in Fertilizer Bulletin No. 2, Control Series. Similar work has been started with fertilizers collected in 1914.

3. Report of the Feed and Dairy Section.

(a) The Feeding Stuffs Law (Acts and Resolves for 1912, Chapter 527).

During the past year Mr. Smith and Mr. Beals have examined 924 samples of feeding stuffs. In accordance with the feeding stuffs law, 1,002 brands of feeding stuffs were registered; some of those registered, however, were not offered for sale, or, if offered, were sold to such a limited extent that they were not found by the inspector.

The spirit of co-operation between dealer and those having in charge the enforcement of the feeding stuffs law has been, on the whole, very satisfactory, and only three cases have been brought for prosecution. The officials having the law in charge are always reluctant to bring cases into court except as a last resort or where the interests of the consumer are at stake, preferring to depend upon publicity and persuasion, if possible.

The importation from foreign countries of feeding stuffs has been increasing for several years. Thus far the amount imported has not affected the local market, the imported feeding stuffs having sold at ruling prices, or, in some cases, for prices in excess of those charged for domestic products. Recently cargoes of corn and wheat feeds have been received from the Argentine Republic, a cargo of dried beet pulp has been brought to Boston from Spain, Canadian wheat feeds have been coming in for some time, and Molassine meal and the Bibby feeds, both English products, are quite extensively sold in Massachusetts. It is also to be noted that barley and dried brewers grain are coming from California by way of the Panama Canal.

The work of this section in connection with the feeding stuffs law for the autumn of 1913 and the winter of 1914 has been published as Bulletin No. 1, Control Series.

(b) The Dairy Law (Acts and Resolves for 1912, Chapter 218).

It is the intent of this act to promote accuracy in the determination of butter fat by the Babcock test. The act applies to creameries, milk depots, departments of milk inspection and

other places where the test is used as a basis for fixing the value of milk or cream. Operators must secure a certificate of competency from the experiment station, all glassware used must be calibrated and machines and apparatus must be inspected once annually.

1. *Examination for Certificates.* — Nineteen candidates have taken examinations and have received certificates.

2. *Inspection of Glassware.* — Six thousand three hundred and thirty-six pieces of Babcock glassware have been tested for accuracy, of which only eighteen pieces were condemned.

Following is a summary for the fourteen years that the law has been in operation: —

Year.	Number of Pieces tested.	Number of Pieces condemned.	Percentage condemned.
1901,	5,041	291	5.77
1902,	2,344	56	2.40
1903,	2,240	57	2.54
1904,	2,026	200	9.87
1905,	1,665	197	11.83
1906,	2,457	763	31.05
1907,	3,082	204	6.62
1908,	2,713	33	1.22
1909,	4,071	43	1.06
1910,	4,047	41	1.01
1911,	4,466	12	.27
1912,	6,056	27	.45
1913,	6,394	34	.53
1914,	6,336	18	.28
Totals,	52,938	1,976	3.73[1]

[1] Average.

3. *Inspection of Machines and Apparatus.* — Mr. James T. Howard, as deputy inspector, has visited and inspected the Babcock machines and apparatus in 80 creameries, milk depots and milk inspectors' laboratories. Only two machines were condemned and conditions were found to be satisfactory in most cases.

Following is a list of creameries, milk depots and milk inspectors' laboratories visited in 1914: —

1. Creameries.

Location.	Name.	Manager or Proprietor.
1. Amherst,	Amherst,	R. W. Pease, proprietor.
2. Amherst,	Fort River,[1]	E. A. King estate, proprietors.
3. Ashfield,	Ashfield Co-operative,	Wm. Hunter, manager.
4. Belchertown,	Belchertown Co-operative,	M. G. Ward, manager.
5. Brimfield,	Crystal Brook,	F. N. Lawrence, proprietor.
6. Cummington,	Cummington Co-operative,	D. C. Morey, manager.
7. Easthampton,	Hampton Co-operative,	W. S. Wilcox, manager.
8. Heath,	Cold Spring,	F. E. Stetson, manager.
9. Hinsdale,	Hinsdale Creamery Company,	W. Solomon, proprietor.
10. Monterey,	Berkshire Hills Co-operative,	F. A. Campbell, manager.
11. Northfield,	Northfield Co-operative,	C. C. Stearns, manager.
12. Shelburne,	Shelburne Co-operative,	I. S. Barnard, manager.
13. Wyben Springs,	Wyben Springs Co-operative,	C. H. Kelso. manager.

[1] Testing done at Massachusetts Agricultural Experiment Station.

2. Milk Depots.

Location.	Name.	Manager.
1. Boston,	Acton Farms Milk Company,	John Colgan.
2. Boston,	Boston Condensed Milk Company,	G. A. Graustein.
3. Boston,	Boston Jersey Creamery,	T. P. Grant.
4. Boston,	Deerfoot Farms,	H. I. Mason.
5. Boston,	Elm Farm Milk Company,	J. K. Knapp.
6. Boston,	H. P. Hood & Sons,	N. C. Davis.
7. Boston,	Llanwhitkell Farms,	E. E. Taylor.
8. Boston,	Morgan Bros.,	A. G. Johnson.
9. Boston,	Oak Grove Farm,	J. Alden.
10. Boston,	Plymouth Creamery Company,	R. Gardner.
11. Boston,	Rockingham Milk Company,	L. G. Sanford.
12. Boston,	Turner Center Dairying Association,	C. E. Small.
13. Boston,	D. Whiting & Sons,	J. K. Whiting.
14. Cambridge,	C. Brigham & Co.,	J. K. Whiting.

2. *Milk Depots* — Concluded.

Location.	Name.	Manager.
15. Egremont,	Willow Brook Dairy,	E. A. Tyrell.
16. Everett,	Hampden Creamery,	R. T. Mooney.
17. Great Barrington,	Edgewood Farm Dairy,	C. H. Freeham.
18. North Adams,	Ormsby Farms,	W. E. Penniman.
19. Pittsfield,	H. H. Prentice & Son,	H. H. Prentice.
20. Sheffield,	Willow Brook Dairy,	F. B. Perry.
21. Springfield	Tait Bros.,	G. Tait.
22. Southborough,	Deerfoot Farms,	S. H. Howes.

3. *Milk Inspectors.*

Location.	Inspector.	Location.	Inspector.
1. Adams,	A. G. Potter.	23. Medford,	W. Joyce.
2. Amherst,	P. H. Smith.	24. Millbury,	F. A. Watkins.
3. Andover,	F. H. Stacey.	25. New Bedford,	H. B. Hamilton.
4. Arlington,	L. L. Pierce.	26. Newton,	A. Hudson.
5. Barnstable,	G. T. Mecarta,	27. North Adams,	H. Tower.
6. Boston,	J. O. Jordan.	28. Northampton,	G. R. Turner.
7. Brockton,	G. Bolling.	29. Plainville,	J. J. Eiden.
8. Cambridge,	W. A. Noonan.	30. Revere,	J. E. Lamb.
9. Chelsea,	W. S. Walkley.	31. Salem,	J. J. McGrath.
10. Chicopee,	C. J. O'Brien.	32. Somerville,	H. E. Bowman.
11. Clinton,	G. L. Chase.	33. South Hadley,	G. F. Beaudreau.
12. Everett,	E. C. Colby.	34. Springfield,	S. C. Downs.
13. Fall River,	H. Boisseau.	35. Taunton,	L. C. Tucker.
14. Fitchburg,	J. F. Bresnahan.	36. Wakefield,	F. S. Bonney.
15. Gardner,	C. W. Shippee.	37. Waltham,	A. L. Stone.
16. Greenfield,	G. P. Moore.	38. Ware,	G. E. Marsh.
17. Haverhill,	H. L. Conner.	39. Wellesley,	R. W. Hoyt.
18. Holyoke,	D. Hartnett.	40. Westfield,	W. M. Porter.
19. Lawrence,	J. H. Tobin.	41. West Springfield,	N. T. Smith.
20. Lowell,	M. Marster.	42. Winchendon,	G. W. Stanbridge.
21. Lynn,	H. P. Bennett.	43. Woburn,	E. P. Kelley.
22. Malden,	J. A. Sanford.	44. Worcester,	G. L. Berg.

4. Miscellaneous.

Location.	Name.	Manager.
Boston, ...	Walker Gordon Laboratory, . .	G. W. Franklin.
Boston, ...	United Drug Company, . . .	J. H. Lane, chemist.
Springfield, ...	Emerson Laboratory, . . .	H. C. Emerson.

(*c*) *Water Analysis.*

Water from private supplies is analyzed by this section at $3 per sample, in order to determine its suitability for domestic use. Analysis for mineral content, the bacterial examination and the analyses of waters to determine their suitability for boilers are not undertaken. Samples from public supplies are not analyzed as all matters pertaining to public water supply are by law placed under the direct charge of the State Department of Health. Ninety-three samples of water were analyzed during the past year, the larger number of which came from wells. Waters sent in containers other than those furnished upon application will not be examined.

(*d*) *Milk, Cream and Feeds for Free Examination.*

This section has analyzed a large number of samples of milk, cream and feeds sent to it by farmers and others. The station reserves the right to analyze only such samples as may be of general interest, and will refuse to make analyses where the samples are not properly taken or where such work is more properly the function of a commercial chemist. With the exception of milk and cream, human food stuffs will not be analyzed except where they are direct products of Massachusetts agriculture.

(*e*) *Testing of Pure Bred Cows for Advanced Registry.*

This work has increased to such an extent that at times it is a severe tax upon the regular work of this section. Four men are constantly employed in making Jersey, Guernsey and Ayrshire tests, while for the Holstein work twenty-two men have been used at different times. During the latter part of the year the

outbreak of foot and mouth disease interfered seriously with the work. From Dec. 1, 1913, to Dec. 1, 1914, 110 Guernsey, 112 Jersey, 23 Ayrshire and a few Holstein yearly tests were completed. Owing to the disorganized state of the work on December 1, on account of the foot and mouth disease, it is impossible to give with any accuracy the number of cows on test at that time. For the Holstein-Friesian Association there have been completed 189 seven-day tests, 5 fourteen-day tests, 6 thirty-day tests, 2 sixty-day tests and 1 sixty-nine day test, the latter being in connection with so-called semi-official work.

(*f*) *Miscellaneous Work.*

In addition to the work already described, this section has made analyses of a large number of samples of milk, feeding stuffs and feces in connection with experimental feeding and digestion tests. It has also co-operated with other departments of the college and State as follows: —

1. With the Bowker Fertilizer Company in making moisture determinations on corn in connection with the awarding of prizes for yield on a uniform water content.

2. With the agricultural department of the college in making analyses of milk in connection with the awarding of prizes at a dairy show held during farmers' week.

3. With the agricultural department of the experiment station in making analyses of corn kernels to determine the effect of frost and other conditions upon the starch and sugar content of the kernel.

4. With Dr. Gates, the station apiarist, in making determinations of beeswax on 33 samples of slum gum in connection with efficiency tests of the beeswax extraction plant.

4. Numerical Summary of Substances Examined in the Chemical Laboratory.

The following substances have been received and examined: 93 samples of water, 606 milk, 1,489 cream, 1 ice cream, 2 butter, 256 feedstuffs, 226 fertilizers and fertilizer refuse materials, 152 soils, 30 lime products, 33 samples of slum gum, 7

samples vinegar and 5 miscellaneous. There have also been examined in connection with experiments in progress by the several departments of the station, 179 samples of milk and cream, 187 cattle feeds and 318 agricultural plants. In connection with the control work there have been collected 1,307 samples of fertilizers and 924 samples of feedstuffs. In addition, 71 samples of coal have been analyzed for the college heating plant. The total for the year was 5,886. This does not include the work of the research section, where many analyses are made in connection with research problems, nor the work under the dairy law already reported.

REPORT OF THE BOTANIST.

A. VINCENT OSMUN.

The writer of this report has been in charge of the department of botany and vegetable physiology and pathology only since October 13. It has been necessary, therefore, to depend upon other members of the staff for information concerning the particular work conducted by each.

During 1914 the botanical work has been mainly along lines previously reported. Information concerning plant diseases and methods of control has been in increasing demand. Several diseases formerly considered relatively unimportant have come into prominence, and a few diseases previously unlisted as occurring within the State have been reported. Among the former may be mentioned a bacterial root and stem rot of celery, which becomes especially troublesome in storage; a similar rot of onion bulbs, sooty blotch of apple caused by *Leptothyrium pomi* (Mont. & Fr.) Sacc., and anthracnose of snapdragon caused by *Colletotrichum antirrhini* Stewart. The first two mentioned diseases present rather difficult and important problems and need investigating. Sooty blotch of apples is a common disease which usually is readily controlled by spraying. During the last season it was more than commonly prevalent, and several growers reported a large percentage of loss from it. The severity of the outbreak may have been due in part to the dusty atmosphere of a dry summer, but more data carefully collected are needed.

Powdery scab of potatoes was found in several market lots said to have come from Maine, but no occurrence of the disease in Massachusetts-grown potatoes was reported. This disease is a serious one in Europe, and has become established in Canada and Maine. Although Federal inspection and quarantine laws

doubtless prevent to a great extent importation of potatoes affected with powdery scab, growers should be alert to detect the trouble in their "seed" tubers, and all suspected cases reported to the station.

The Rhizoctonia disease of potatoes seems to have been quite general throughout the State the last season. The relative importance of this disease in the State is not known, but it has not formerly been considered serious. In several other States, notably Colorado, New Jersey and Maine, it is said to cause considerable loss.

Fire blight of apple and pear trees, though prevalent in the State the last summer, was not as virulent as in 1913, apparently responding to natural check.

The chestnut blight, caused by *Endothia parasitica* (Murr.) Anderson, has continued to spread throughout the chestnut belt, but sufficient data are not at hand to determine whether the spread has been as rapid or the damage as great as in former years. However, it is our opinion, based on limited observation, that this disease has been held somewhat in check by natural causes, possibly climatic conditions, and that the case of the chestnut in Massachusetts is perhaps not so hopeless as it once appeared.

Diseases of tobacco, aside from mosaic disease, have received scant attention by this station. There have been many requests for help in the control of such diseases. The tobacco crop is an important one in the State, and growers are asking that the station co-operate with them in the investigation of some of the more important troubles with which they have to contend. Such work is under consideration, and it is hoped that it may be undertaken during the coming summer.

Diseases for the first time on record as occurring in the State are apple cankers, in which the causal organisms were *Coryneum foliicolum* Fckl. and *Phoma mali* S. & S., both of these fungi being found associated in other cankers with the perfect stage of *Glomerella rufomaculans* (Berk.) Spauld. and von Schrenk; anthracnose of cyclamen, caused by *Glomerella rufomaculans.* var. *cyclaminis* P. & C.; a dry rot of stored potatoes, due to *Verticillium albo-atrum* McA.; silvery scurf of potatoes, caused

by *Spondylocladium atrovirens* Harz.; a secondary rot of stored potatoes, due to *Stysanus stemonitis* Cda.; and a fruit rot of egg-plant, caused by *Botrytis fascicularis* (Cda.) Sacc. The cyclamen disease, although previously described,[1] needs further investigation and is now under observation by the writer.

The appearance of the silvery scurf on a seed tuber grown in the eastern part of the State is cause for some concern among potato growers. While not considered serious, the advent of this disease means one more enemy for the grower to combat. This disease appears on the surface of the tuber as a darkened area throughout which are scattered many minute black specks. The latter are sclerotia, similar to those of the Rhizoctonia disease, but very much smaller. The trouble is not easily detected on unwashed tubers but is conspicuous on clean tubers. It causes shrinking, due to loss of moisture through the diseased outer tissue. The disease seems difficult to control, not yielding to ordinary "seed" disinfection as practiced for scab, and growers should, therefore, reject and destroy all seed tubers which show signs of this trouble.

At present the station is largely dependent for plant disease data upon casual reports received in correspondence from persons seeking information concerning remedial measures. The appearance of new diseases, the apparent increased importance of others, and the doubt concerning the importance of still others, suggest a pressing need of improving our facilities for obtaining such information. Other States have made and have under way systematic plant disease surveys. No such systematic investigation has ever been undertaken in Massachusetts, though every one familiar with phytopathological procedure recognizes such work as of fundamental importance.

The number of requests for seed separation and purity and germination tests also has increased. Increased demand from commercial houses for the cleaning and separation of large quantities of seed has made necessary some curtailment of this phase of the seed work. The usual run of seed separation cannot be considered as experimental work, and trained experts employed by the station for investigation should not be obliged

[1] Patterson, Flora A. Disease of Cyclamen caused by a Variety of *Glomerella rufomaculans*. U. S. Dept. Agr., Bur. Pl. Ind. Bul. 171, 12–13, 1910.

to devote time to it. It seems entirely proper that the station should investigate and improve methods, but it is felt that it should be left to the seedsmen to adopt such methods in separating their own seed. This they could do at small initial cost.

Lack of equipment and facilities for making purity and germination tests has made difficult the handling of this work. In this, as in seed separation work, the number of receipts from commercial houses has been excessive.

In connection with the seed work a new device for counting seed [1] and improvements in apparatus for separating tobacco seed have been devised. Methods employed in germination tests are in need of improvement, and it is hoped that investigations looking towards this may be undertaken in the near future.

Miscellaneous experimental work, including spraying, weed eradication, tests of soil and other fungicides, and tests of radio-active substances as fertilizers, has been carried on, and some satisfactory results obtained.

Experiments to determine the effect of certain crude by-products on the control of potato scab [2] were last season transferred from the tile and pots to field plots. Slight beneficial results were obtained, but the work will be continued further before a detailed report is made.

Radio-active substances as fertilizers have aroused much interest, and at the request of a manufacturer, experiments are being conducted in the greenhouse to determine the effect of these materials on seed germination and growth of crops.

Experimental work has continued on the exclusion of roots from tile drains by packing the joints with creosoted excelsior.[3]

Other investigations are under way concerning oil injury to fruit trees and on repellents to prevent gnawing of fruit tree bark by rabbits.

The following Adams fund projects have been authorized: —

1. Study of the physiological reaction of plants to light intensity and moisture in relation to the burning of foliage by sprays and fumigants.

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[1] Clark, Orton L. A Simple Device for Counting Seeds. Science, N. S. XLI, 132, 1915.

[2] Stone, G. E., and Chapman, G. H. Experiments relating to the Control of Potato Scab. Mass. Agr. Exp. Sta., 25th An. Rept., Pt. I., 84–96, 1913.

[3] Stone, G. E., and Chapman, G. H. Experiments relating to the Prevention of the Clogging of Drain Tile by Roots. Mass. Agr. Exp. Sta., 23d An. Rept., Pt. II., 35–42, 1911.

2. Study of the optimum conditions of light for plant response.

3. Mosaic disease of tobacco and allied diseases.

4. Influence of electrical stimulation on nitrogen fixation.

A large amount of data has been gathered in the work on the first project, and results for publication should soon be available.

Progress on the second project has been largely in the development of methods and apparatus preliminary to starting investigation of the main problem.

Investigation of the mosaic disease of tobacco has been under way for some time. The completion of the work awaits the result of certain field experiments to be conducted during the present year. The relative activity of enzymes in healthy and diseased plants has been studied in detail during the last six months. Studies are in progress on methods of control, both by inoculation and absorption of chemicals, and on the effects of different lights, and some apparently favorable results have been obtained. These studies are to be continued during the ensuing year.

Work has begun on the effect of electrical stimulation on nitrogen fixation by *Pseudomonas radicicola* and *Azotobacter*, and satisfactory apparatus and methods for accurate work have been developed. The experiment now being conducted deals particularly with the effects of direct current electricity. It is planned to follow this shortly by similar experiments with alternating current electricity and with static charges. The maximum and minimum currents have been determined more or less satisfactorily.

The results of investigation on electrical injuries to trees, which had extended over a number of years, were published in October as Bulletin No. 156.

REPORT OF THE ENTOMOLOGIST.

H. T. FERNALD.

During the year 1914 little has been attempted along new lines of investigation, a sufficient number of subjects previously undertaken remaining incomplete to occupy all the time available. This report, therefore, indicates mainly progress in research already undertaken at the time of the report for 1913.

A part of the regular work of the station is attending to correspondence with reference to insects. During the past year this has amounted to about 2,800 letters. In most cases the inquiries have been for information about the less well-known insects, which has, of course, involved the expenditure of more time than was the case a few years ago. In a number of instances the information desired was not available, requiring considerable investigation, and in some cases the rearing of material sent in and the devotion of considerable time to the work.

Among the lines of investigation continued were a farther observation of the dates of hatching of the young of our various common destructive scales; a study of the distribution of pests in different parts of the State in order to determine the existence of sections where some might prove of little or no importance: the testing of a number of insecticides, and the completion by Dr. Smulyan of his work on the Marguerite fly, which has now been published as a bulletin from the station.

Experiments for the control of the onion maggot were continued last spring, but an unanticipated scarcity of this insect made these of less value than was anticipated, and the work will need to be repeated and extended this coming season.

Under the Adams fund, farther study of the Sphecidæ as parasites has been prosecuted with satisfactory progress, and spraying with pure materials as a basis for investigations on

commercial materials to follow has resulted in the collection of several thousand records on this subject.

The usual amount of care has been given to the collections, in order to keep them in proper condition and protect them from museum pests, and numerous additions, both of adults and to various stages in the life history of many kinds, have been made.

REPORT OF THE HORTICULTURIST.

F. A. WAUGH.

The work in horticultural lines has progressed favorably during the year, but without any special changes in plan or policy. The principal work has been that carried on by Dr. J. K. Shaw, whose separate report is appended. The general plan with regard to the work conducted by Dr. Shaw has been to bring the experiments in plant breeding to a tentative conclusion and to lay greater emphasis upon the research work in pomology, especially upon the extensive experiments in the mutual influence of stock and scion.

Considerable emphasis is also placed upon other practical and scientific experiments in lines of fruit work conducted by Dr. Shaw and Prof. F. C. Sears.

It becomes plainer year by year that the scope of investigations in horticulture should be extended. This desire touches especially the work in floriculture and market gardening, two very important industries of Massachusetts. In spite of their importance very little work has been done directly by this station upon technical problems in these fields.

It seems clear to me that we should make plans to take up definite experimental work in these lines at the earliest practicable moment.

ANNUAL REPORT OF DR. J. K. SHAW.

During the calendar year just closed no new work has been inaugurated but previously established projects have been carried on with a fair degree of success. During February about 9,000 grafts were made for the root and scion project. Some of these made a very good growth, and others did not succeed so well, owing probably to a combination of circumstances, the

principal one of which was unusually severe weather during the winter. The two-year old trees belonging to this project were reset on the Tuxbury land and made good growth during the summer. The scions showed a percentage of rooting varying from 0 to 100 per cent., according to the variety. Seedling roots were cut from those showing roots from the scion, and most of them made good growth during the summer. The stock set in the spring of 1913 made excellent growth last summer, and I have hopes that it will show a good percentage of rooted trees. A crop of soy beans was grown on the proposed experimental orchard on the Tuxbury land, plowed in in the fall, and the land sowed to rye. This should result in placing the land in excellent condition for setting the orchard the coming spring. About 2,000 feet of tile were laid in this orchard which should be sufficient to drain the wet portions, with the exception of the south end of the field; this will need to be drained during the coming summer or fall, and nearly enough tile are on hand for the work.

Considerable time was given during the summer to the study of leaf and twig characters on apple trees in order to become thoroughly familiar with the different varieties in anticipation of the study of them as they grow on different roots. It is hoped to continue this in the future, with the possible result of constructing a key by which nursery trees may be identified. A paper on the subject was read before the Society of Horticultural Science at the Philadelphia meeting which will appear in the forthcoming report of this society.

In co-operation with the United States Weather Bureau nine weather observation stations were maintained during the summer months in Buckland and adjacent territory, the Weather Bureau supplying equipment for four stations and the experiment station for the other five. The data accumulated promise to be extremely interesting, and it is hoped to make a preliminary study of them during the present winter. This should be continued for successive years in order to measure the seasonal differences and to confirm results of the several individual years. Considerable time was spent during the winter of 1913 and 1914 upon the study of records secured during the summer of 1913 in the college orchards. These data are being held for

consideration and publication with those secured in these outside localities.

The work in plant breeding has been a continuation of that previously carried on with beans, squashes and peas. With the plants grown during the past summer we have records on over 30,000 bean plants, including about 120 crosses, involving something over 20 varieties. This work has resulted in the accumulation of an immense mass of data bearing on the inheritance of pigmentation. This matter is being worked over at the present time, and it is hoped that it may be ready for publication in the spring as a joint publication of Mr. Norton and myself. While this leaves many questions of inheritance of pigments and pigment patterns unsettled, it throws a great deal of light not only upon the manner of inheritance of pigments and pigment patterns, but also upon the mode of inheritance in general.

The work with squashes has been confined to an attempt to isolate pure races, as previous work had indicated that our common varieties of squashes are a miscellaneous collection of heterozygous forms. Plants of the third self-fertilized generation almost completely failed to grow during the past summer. The attempt to grow this generation will be repeated next summer to discover whether this is the necessary result of continued self-fertilization. We were fortunate in having a surplus of seeds of the previous generation which enabled us to repeat the selfing last summer. Individual squashes from each vine were photographed last fall, this having proven the most satisfactory method of recording the different types which are isolated from commercial varieties.

With peas, the work of selecting within the pure lines was continued by growing and measuring of several thousand plants during last summer. A compilation of the results of this third season of selection gives negative results, the difference between the vines selected for length and those selected for shortness being less than during the first year that selection was practiced. This should be continued for a period of years to discover whether this is a permanent result or whether only accidental for this particular year.

The study of the correlation between seed weight and vine length was continued, several thousand plants being grown and measured, each individual seed having been weighed before planting. This shows, as in previous years, the marked correlation between these two characters. It is hoped to prepare the results of this work for publication in the near future.

REPORT OF THE METEOROLOGIST.

J. E. OSTRANDER.

During the past year the work in this department has been continued along the usual lines. Changes in the character of the records or the methods of observation cannot well be made if the results are to be of value for comparison with existing records.

Besides the compilation of the usual data and the arrangement of the records in permanent form, a summary of existing records for twenty-five years was prepared and published as Bulletin No. 153, in June. This bulletin has been sent out to a selected mailing list, and is found useful in answering many inquiries addressed to this department concerning the matter of climate, rainfall, temperature and wind movement.

During the year we have acted as one of the voluntary stations of the United States Weather Bureau, and have furnished special data for publication in the monthly on climatological data of the New England section.

The usual monthly bulletins giving the results of the observations at this station have also been published and distributed from here.

REPORT OF THE VETERINARIAN.

JAS. B. PAIGE, D.V.S.

During the past year the activities in the veterinary department have been directed along lines of correspondence, diagnosis and investigation.

Each succeeding year a larger number of letters is received from the stock owners of the State, asking for information relative to the cause, prevention and treatment of simple ailments that occur among their animals. In every instance the receipt of such communications is acknowledged, and, where possible, the information asked for given. It frequently happens that specimens of diseased material accompany the communication. In such instances it is the practice in the department to examine the specimen and make a report to the sender upon the nature of it. In this way we are able to keep in touch, to a considerable extent, with the nature of the various animal diseases that occur in different parts of the State. In this connection it is particularly interesting to note that avian tuberculosis, formerly known to exist to a very limited extent among the flocks in Massachusetts, has developed extensively within the past few years and has now become quite general in many sections. Not only has the disease been diagnosed in specimens of common fowl sent to the department, but also in ring-necked pheasants from a large flock kept in confinement upon a private game preserve.

The strict investigational studies have been directed toward the development of methods for the diagnosis of bacillary white diarrhœa in adult fowls and the prevention of hog cholera by the use of anti-hog cholera serum.

The method for the diagnosis of bacillary white diarrhœa in fowls is given in full in a bulletin contained in the last annual report of the experiment station. To make a practical test of

the method a number of birds was selected from a flock in which there was every evidence to show that there were many individuals harboring infection and producing eggs containing *Bacterium pullorum,* which, when incubated, produced chicks that soon succumbed to an attack of white diarrhœa. Application of the agglutination test to this part of the flock, previously leg-banded for identification, and the subsequent elimination of every individual showing symptoms of infection, gave most gratifying results in the season's hatch of chicks. Of 1,000 chicks hatched from eggs of the tested hens, not one died of white diarrhœa. The previous season, before the bearers of infection had been eliminated from the flock from which eggs were saved for hatching, only 200 chicks, of 2,000 hatched, survived the ravages of disease, 1,800 dying of *B. pullorum* infection. This line of work has been carried on in the department by Dr. G. E. Gage and his assistants.

The hog cholera investigations were started in January, 1913, in co-operation with the Massachusetts Department of Animal Industry, and are in progress at the present time. Since the above date many experiments of a strictly scientific character have been conducted at the experiment station, and also practical tests made in several different herds of hogs, to determine the value of anti-hog cholera serum as a cure and preventive of hog cholera. During the period that the work has been in progress no less than 3,283 hogs, on fifteen different farms in the State, have been treated. While the results have not been uniform in the different herds, they have, on the whole, proved satisfactory, and promise eventually to provide a method for the protective treatment of hogs against cholera infection. Little or no curative effect has been observed from the use of serum on hogs actually suffering from cholera.

REPORT OF THE POULTRY HUSBANDMAN.

J. C. GRAHAM AND H. D. GOODALE.

Steady progress has been made on our original projects. A new viewpoint of the problem of egg production has been secured which leads to the belief that it will have to be studied analytically, considering the factors of broodiness, age, egg cycles, rate of laying, longevity, maturity, each by itself as far as possible. Certain families are better producers on the whole than others. That the male is a factor in determining the egg production of his daughters appears to be demonstrable, but not in the same sense as described by other students of the problem. The winter egg cycle in Rhode Island Reds, if present at all, is not marked off from the spring cycle by a fall in egg production. The stimulus that induces the hen to visit the nest is not always associated with the deposition of an egg. Additional data substantiating the individuality among fowls in relation to the hatching quality of their eggs and viability and rate of growth of chicks have been secured. Further work on morphogenesis has been done, particularly in relation to the influence of the primary sexual organs to the secondary sexual characters. In one instance an apparently successful graft of ovaries was made in a castrated cockerel, feminizing it to a large degree.

A new building 18 by 72 feet has been provided, having laying accommodations for 300 hens. This gives us a total capacity for 450 laying birds. By means of movable partitions the new building can be transformed into a breeding house for pen matings.

Mr. Sayer resigned the first of October. Late in December a satisfactory man was finally secured, Mr. Austin Brown. In the meantime the egg production was decidedly unsatisfactory, due perhaps to improper care.

ELECTRICAL INJURIES TO TREES.

GEORGE E. STONE.

Introduction.

In 1903 there was issued from this station a bulletin dealing with some new phases of the subject of electrical injury to trees.[1] This bulletin has been out of print for some time, and as many new observations — the result of years of careful study of the influence of electricity on plants — have been made, it has been thought wise to issue another edition. Many people are quite unfamiliar with certain types of injury from electricity occasionally to be found, and even those directly responsible often do not realize how serious the harm done is likely to prove.

The increase in electric railroads, electric lighting systems and telephone lines, whose wires are usually located near the tree belts of our cities and towns, has made necessary a lamentable amount of disfiguring pruning. When strung too close to trees, wires also often cause serious injury by burning, and sometimes mechanical injury is done; and even lightning discharges will cause harm when guy wires are attached to trees. (See Fig. 1, Plate I.)

Both the alternating and direct currents are used. They produce different physiological effects on plant life, the alternating current apparently being less injurious than the direct; and when either is used at a certain amperage it acts as a stimulus to the plant, and growth and development are accelerated.

There are minimum, optimum and maximum currents affecting plants. The minimum represents that strength of current which just perceptibly acts as a stimulus, and is a very insignificant current. The optimum is that producing the greatest stimulus — about .2 milliamperes — and the maximum, that causing death. (See Fig. 3.) Between the optimum and the maximum there is a strength of current that causes retardation in the plant activities, this being represented between R and MX in Fig. 3. The maximum current necessary to cause death is very variable. The direct current has a less stimulating effect than the alternating, and on account of its electrolyzing effect is capable of causing more injury to vegetable life than the alternating current.

Most of the injury to trees from trolley or electric light currents is local; *i.e.*, the injury takes place at or near the point of contact of the wire with the tree. This injury is done in wet weather when the tree is covered with a film of water, which provides favorable conditions

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[1] G. E. Stone, "Injuries to Shade Trees from Electricity," Bul. No. 91, Mass. (Hatch) Agr. Exp. Station, 1902.

for leakage, the current traversing the film of water on the tree to the ground. The result of contact of a wire with a limb under these conditions is a grounding of the current and burning of the limb due to "arcing." The vital layer and wood become injured at the point of contact, resulting in an ugly scar and sometimes the destruction of

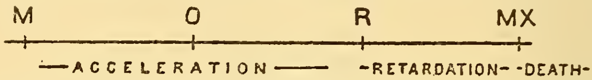

FIG. 3. — Diagram showing range of electric current affecting plants. M = minimum; O = optimum, or current producing greatest stimulus; MX = maximum, or death current; R to MX = retardation current.

the limb or leader. In a large number of tests made by the aid of sensitive instruments with guy wire and other connections of wires to trees we have never found any leakage during fair weather, or when the surface of the tree is dry. Since the amount of current that can be passed through a tree depends upon the resistance and electromotive force, we shall consider this resistance at some length.

ELECTRICAL RESISTANCE OF TREES.

The electrical resistance shown by trees is quite great, otherwise more injury might result from contact with live wires. The following table (I.) gives the electrical resistance of 10 feet of a maple and elm, each tree being about 2 feet in diameter and the electrodes 10 feet apart. These resistances were determined by a Western Electric Company combination bridge rheostat and galvanometer, and a large battery. Other resistances, however, have been obtained by means of the electro-motive force, and a known current passed through the tree, the two methods agreeing in their results quite closely. The table, which is taken from one of our previous publications,[1] is one of many.

TABLE I. — *Showing Average Electrical Resistance (in Ohms) of Maple (Acer saccharum Marsh) and Elm (Ulmus americana L.) covering a Period of nearly Three Months. Resistances taken on the North, South, East and West Sides of the Trees about Midday. Electrodes 10 Feet Apart.*

TREE.	Month.	East.	South.	West.	North.
Maple,	April,	18,550	18,185	20,500	20,800
	May,	21,075	20,550	21,650	24,500
	June,	19,775	19,761	21,883	22,550
Elm,	April,	24,300	26,075	25,700	24,275
	May,	13,025	15,750	14,825	17,375
	June,	14,992	18,608	17,508	17,383

[1] Electrical Resistance of Trees, G. E. Stone and G. H. Chapman, 24th Ann. Rept. Mass. Agr. Exp. Station, 1912, Pt. I., p. 144.

It will be noted that these resistances were taken on the east, south, west and north sides of the trees, and represent averages of weekly observations. The lowest resistance (data not given in the table) obtained from the maple was 14,000 ohms, and the highest, 33,000 ohms. In the case of the elm the lowest resistance was 6,300 ohms, while the highest was 29,400 ohms. These resistances are relatively low, for in cold weather they often exceed 100,000 ohms. The lower resistance in all cases corresponds to periods of high temperatures, and the highest to periods of the lowest temperature. The difference shown by the various sides of the tree is also related to temperature.

As might be expected, there is considerable difference in the electrical resistance of various trees as well as of the different tissues found in trees. The heartwood, sapwood, cambium, bark and sieve tubes possess quite different properties and functions, and their electrical resistance would naturally vary to a large extent. The living cells containing protoplasm, such as are found in the cambium, present the least resistance, as shown by various observations on lightning discharges. The minute burned channel, caused by comparatively insignificant lightning discharges, follows down the cambium, indicating that this is the line of least resistance. Moreover, by driving electrodes into a tree to different depths and measuring the resistance it can be shown that the least resistance occurs in the region of the cambium.

The electrical resistance, however, may average throughout the year 25,000 ohms more or less in 10 feet of the trunk of a large maple tree. This constitutes a comparatively high resistance. The resistance of the sapwood is very much greater, and probably that of the heartwood is even higher than that of the sapwood.

In determining the electrical resistance it is necessary to know the path or course of the current, and the only manner in which the resistance of different tissues can be determined accurately is by isolating the tissues. By girdling a tree and scraping the trunk down to the solid wood we can get the resistance of the wood. Mr. G. H. Chapman found the resistance of a freshly cut rock maple stem, 1½ inches in diameter, to be 70,000 ohms with the bark on, but 150,000 ohms when the bark was removed. The electrodes were 1 foot apart. Some of our experiments indicate that next to the cambium the phloem has the least resistance, followed by the sapwood. The outer bark appears to offer the most resistance, but when wet the resistance may be somewhat decreased owing to the less resistant film of moisture on the bark. The resistance obtained from an elm tree in summer, with the electrodes 10 feet apart and in contact with the cambium, was 10,698 ohms, whereas when the electrodes were inserted into the middle of the cortex or phloem we obtained 11,300 ohms resistance. When driven ¼ inch into the wood the resistance was 98,700 ohms. The outer bark gave 198,800 ohms resistance, but when the electrodes were inserted slightly

deeper into the bark we obtained 109,900 ohms. It must not be understood, however, that these readings gave the electrical resistance of 10 feet of the various tissues enumerated except in the case of the cambium, since if these tissues were isolated the resistance would be much greater in some cases. They show that there is much difference in the resistance of different tissues, but in all cases we obtained merely a resistance of the cambium, together with that of a part of the other tissues which the current had traversed from its various points of entrance to the cambium. It is quite evident from our observations on the resistance of trees that the cambium gives the least resistance, the phloem next, and it is not at all unlikely that in some trees there may be some variation in this respect.

The resistance given by small tree trunks and woody stems, even for small distances, is quite large. About 4 feet of a young pear tree, including the root system, with a maximum diameter of stem equal to 1 inch, gave a resistance of about 300,000 ohms, and the resistance given by a tobacco plant, in which the distance between the electrodes was only 14 inches, was much higher (110,000 ohms to 165,000 ohms) than that shown by most trees at corresponding temperatures.

The water and various salts in the living plant undoubtedly play a rôle in resistance, and it might be expected that the various plastic substances would influence resistance.

The cambium ring is very insignificant in size, and even on a large tree the total area is small. In all probability it is the protoplasm itself which offers the least resistance to the transmission of an electric current; and even if there were no continuity it would be necessary for the current to pass through a great many cell walls even for comparatively short distances on the trunk. In case the protoplasm was continuous or there existed continuity, the strands would be so very small that they would undoubtedly offer some resistance. Whatever conditions prevail, trees show relatively high electrical resistances, a feature which is no doubt of some biological importance as trees are often struck by lightning. The high resistance of trees, therefore, is undoubtedly a protection in case of lightning strokes, since often the heat developed is enough to do only slight injury. On the other hand, if trees possessed tissue with relatively small electrical resistance they would be much more subject to injuries from burning from lightning strokes, and would be more seriously affected by currents from high-tension wires. The electrical resistance of trees is so high that it is doubtful whether injury ever occurs to them from contact with low- or even high-tension wires except that produced by grounding when the bark is moist. Any escaping current from transmission lines that can be transmitted even through the least resistant tissue is likely to be insignificant.

Effects of Alternating Currents.

The alternating current systems employed for lighting purposes vary greatly in their potential. Cases of burning from alternating currents are more numerous than those from direct currents because trees are brought into more frequent contact with the wires, and owing to the higher potential more leakage is likely to occur. The high and low voltage lines may vary from 100 to 100,000 volts. The high-tension systems are invariably constructed across country, and are naturally not brought into very close proximity to shade trees. No injury to trees whatever occurs from the low voltage (110-volt) lines, but the lines of higher potential found on streets constitute a source of danger to trees. The higher the electrical potential the more dangerous the wires become to trees, for owing to the lessened effectiveness of the ordinary insulation, more leakage occurs and consequently greater opportunity for burning.

The effects of alternating currents on trees are local, producing injury only near the point of contact with the wire. Such contact results in death of that part of the tree, and if it is a leader or a large limb it usually has to be sacrificed. In no case, to our knowledge, has an alternating current caused the death of a tree, although it may burn or disfigure the tree so badly that it amounts to practically the same thing. It is doubtful whether the current from a fairly high potential wire would kill a large tree under any circumstances. It is different in the case of small plants, as has been frequently demonstrated in the laboratory, although the current must produce heat enough to kill the protoplasm. Owing to the close relationship between the maximum temperature required to kill a plant and that induced by electrical current, the collapse of the plant tissue in such cases is therefore due to the heat rather than to any specific electrical shock, as it is possible to pass the same current through larger plants where heat is not generated without causing any collapse of the tissue. The ordinary house circuit wires are perfectly harmless to trees, and it seems strange that a judge could render a verdict to the effect that an ordinary insulated 110-volt house circuit was responsible for the death of a tree whose terminal branches were located within 3 feet of it. This is the only court record of which we know where such a judgment has been given.

Very high-tension line wires are not provided with insulation and are known to affect the atmosphere surrounding them to a considerable extent. Any increase in the electrical potential of the atmosphere if not too high would favorably affect vegetation in general.[1]

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[1] There is evidently much difference in plants in this respect. A crop of radishes showed a gain of 57 per cent. when subjected to an average atmospheric potential of 167 volts, whereas an electrical potential equal to 500 or 1,000 volts is beyond the stimulation zone for some plants (16th Ann. Rept. Mass. Agr. Exp. Station (Hatch), 1904, p. 31).

It has been suggested that arc lights are injurious to trees, although we have never seen any cases of injury. It is well known that electric light is different from sunlight in its effects on plants, and it stimulates photosynthesis in proportion as it resembles sunlight in its rays. Some artificial lights contain rays that may act injuriously on small plants and in other ways modify their development, but even if a tree in close proximity to such a light should die it is no proof that it has been injured by this cause, as there are so many other causes for the death of trees.

Effects of Direct Currents.

Most of the direct currents affecting trees are those used for operating electric railroads. Trolley feeders may be at 500 to 550 volts. Ordinarily the burning from direct currents is similar to that produced by the alternating current in being largely local or confined mainly to the point of contact with the wires. The feed wires cause no burning except when the tree is moist, in which case grounding takes place.

We have made a number of experiments, using large trees and small herbaceous plants, with direct currents from electric railroads showing the amount of current passing through trees, etc. In a number of instances a wire was passed from the tree to the rail or ground, and another wire was connected to a bare feed wire (450 to 500 volts) leading to some other portion of the tree, a milliammeter being placed in the circuit to obtain the actual current. The results were as follows: a young pear tree, 2 feet 8 inches in height, and 1¼ inches in diameter at the base, which had been growing one year in a box 14 by 16 by 9 inches, and provided with a copper plate in the bottom in direct contact with the roots, showed a current of 2.2 milliamperes ($\frac{1}{454}$ ampere) when one electrode leading to the rail was connected with the copper plate, and the other leading to the feed wire joined the top of the tree; 16½ feet of a maple tree 18 inches in diameter gave 25 milliamperes ($\frac{1}{40}$ ampere), and 7 feet of the same tree gave a current of 45 milliamperes ($\frac{1}{22}$ ampere). Connections made with a poison ivy (*Rhus toxicodendron* L.) plant growing on a tree showed in most cases similar results when the electrodes were inserted into the stem 2 inches apart. A stem ¾ inch in diameter gave a current equal to 4.4 milliamperes ($\frac{1}{227}$ ampere); ½ inch in diameter, 25 milliamperes ($\frac{1}{40}$ ampere); and another of the same size, 50 milliamperes ($\frac{1}{20}$ ampere). In the latter case, and some others not included here, the currents went down from 50 milliamperes to nothing almost instantly. From these experiments with ivy it appears that the current burned out the cambium or vital layer of the stem, leaving the dry and highly resistant wood which was unable to transmit a perceptible current.

In another experiment young sunflowers and tomato plants grown in 3-inch pots, with copper plates at the bottom, were treated from a

direct current dynamo which generated an electro-motive force of about 60 volts. The plants were from 6 inches to 2½ feet high, and ⅛ to ¼ inch in diameter. When the current passed through 16 inches of the stem and copper plate to the bottom of the pot, a sunflower plant 3/16 inch in diameter gave scarcely perceptible readings; but when the current passed through only 1 inch of the stem and root to the copper plate at the bottom, the maximum current was ⅚ milliampere (1/384 ampere). This caused blackening and death of the tissues, perceptible a few hours afterwards about the points of insertion of the positive electrodes into the stem, and the plant was girdled for about two-thirds of its circumference. Very similar results were obtained with other sunflower plants treated in the same way. A plant 30 inches high and ¼ inch in diameter, subjected to a current of 10 milliamperes for some minutes, was not injured to any extent. In this case the current passed through about 1 inch of stem and ½ inch of soil. A young, succulent tomato plant, ⅛ inch in diameter and 5 inches high, was instantly killed when treated in the same manner with a current of 20 milliamperes, and a current of 2 and 3 milliamperes of 30 to 60 seconds duration accomplished the same result. In all the tomato plants considerable heat was developed. In one case in which an alternating current was used the plant lived for a number of days after the tissues had changed color and the plant had collapsed, as the vascular bundles or water-conducting tissues were not injured.

In the experiments cited all the injuries occurring were due to the effects of heat generated by the current. The experiments also showed that the strength of current which will kill one plant will produce not the slightest effect on another; in other words, the maximum current for each individual varies materially. Small, tender plants possess a maximum much below that of woody plants. The experiments were all carried on under normal moisture conditions; but when trees with a more or less thick bark are drenched with rain the conditions are quite different. A large maple tree which was in circuit with a feed wire (500 volts) and rail of an electric road gave a current equal to 70 milliamperes (1/14 ampere) with the electrodes placed vertically 1 foot apart. These connections were left on the tree for several months. The observations were made on dry days, and no heat developed with this current. During periods of wet weather considerable heat always developed, especially at the positive electrode, but not enough to melt the soft solder which connected the wires with the electrodes.

Examination of the tree ten months later showed that a portion of the tissues near the electrodes had been killed. After removing the dead bark an oval space 6 by 11 inches was found to be dead about the positive electrode and a space about 1½ by 3 inches near the negative electrode. The burned area about the positive electrode was about

95 per cent. greater than that occurring about the negative electrode. In each case it extended about twice as far above and below the point of contact as out to the sides of the electrodes, thus showing a tendency of the current to spread laterally as well as vertically, but more largely vertically.

The immediate area around the electrodes was more affected than that further remote. There was an area of tissue about 5 inches long between the large and small oval burning that was uninjured, showing that burning was confined about the electrodes. The current traversing the film of water on the bark between the electrodes was not sufficient to destroy all of these tissues at that point.

If a milliammeter had been placed in the circuit when the tree was wet a greatly increased current would have been detected, since the current in this case traversed the less resistant film of moisture on the bark. But the electrical resistance of the vital layer under such conditions would remain practically the same as when the tree was dry. The burning and injury in this case resulted from the heating of the film of moisture, which became so intensely heated that the vital tissue was destroyed, especially near the point of insertion of the electrodes. The more the film became heated the greater was the lessening of the resistance and increase of the current.

Practically all of the burning of trees from either alternating or direct currents occurs in this way, since the high electrical resistance characteristic of trees does not permit injurious currents to pass through their tissues.

Death of Trees from Direct Current.

Instances are known in which large trees have been killed by direct currents used in operating electric railroads. So far as we know attention was first called to these cases in Bulletin No. 91, issued by this station, but since the publication of this bulletin other cases have been observed in which the escaping current had burned and girdled the trunks for a distance of 5 to 10 feet from the base, the point of contact of the feed wire with the limb 18 or 20 feet above, showing little or none of the characteristic local burning effects usually observed in ordinary cases of grounding. In fact, the difference between the burning from direct currents in these cases and that from ordinary cases of electrical injury may be seen at a glance. On electric railroad systems the so-called positive current almost always traverses the overhead feed wire where the injury (burning) takes place. This differs only slightly from that produced by low-tension alternating current wires. In all cases of death from direct current electricity that have come to our notice the rail was positive, and the overhead feed wire was negative, constituting what is called a "reversed polarity." How common this practice is we cannot say, but apparently it has been done inten-

tionally at times to prevent electrolysis as well as unintentionally by various companies, and is responsible in quite a few instances for the death of shade trees near electric railroads. There is much greater opportunity for extensive burning in the case of reversed polarity than in the regular systems employed. The moisture conditions of the soil and bark are such as to reduce the resistance, and in consequence the film of water and water-soaked bark become intensely heated, destroying the living tissues and girdling the tree to a considerable distance. The part of the trunk towards the rail is almost invariably the most severely affected. In the cases observed some years ago, where the current was reversed, there were no deep burning effects on the tree either above or below, — the rule when the overhead feed wire is positive (as is usually the case) and in direct contact with the tree. Moreover, the affected areas about the base of the tree are decidedly larger than when a positive overhead feed wire comes into contact with limbs. The entire area between the base of the tree and the overhead wire is not, as a rule, affected, although the extent of injury may vary somewhat. The injury from burning is confined to a space around the overhead wires, and also to the base of the tree. On the elm shown in Fig. 8, Plate IV., the burning was caused by a reversed system, and there was only slight injury at the point of contact with the overhead wire, while at the base about 6 or 7 feet of the tree was affected. This injury takes place when the soil and bark of the tree are moist, and may occur during a single period of excessive moisture, or intermittently. In some instances trees show serious effects a short time after the current has been reversed, when the bark will become loose and later fall off. The writer has observed both elms and maples — some of them 2 feet or more in diameter — which have been killed in this way. In some cases the trees were not more than 3 feet from the rails, while in others the distance was considerably greater.

In one well-planted city having extensive street railways, 51 trees were reported killed or so badly injured as to be of no value, 67 had large limbs removed, and many more were saved by removing limbs likely to come into contact with the wires. According to Mr. G. A. Cromie,[1] who had these under observation, the injured trees were in some cases located from 200 to 1,000 feet from the track. Some of the injury took place on streets having wires but no electric railways, and it is surmised that the ground connections were made through several pipe lines, located near the trees, which led very close to the electric railway. Mr. Cromie states that the effects on the trees were noted shortly after the street railway had changed its system, *i.e.,* using the rail to carry the positive, and the overhead wire the negative or return current. The trees in contact with the overhead wire became electri-

[1] G. A. Cromie, "Scientific American" supplement, No. 1985, p. 40, Jan. 17, 1914.

cally charged, and when wet it was impossible for linemen to work on them. Under these conditions the insulation was much less efficient, and even wooden sleeves imbedded in coal tar and rubber proved of small use in preventing leakage, but otherwise there was little or no trouble from burning.

We were able to examine only a few of these trees, most of them having been removed at the time of our observations; but a large percentage showed a characteristic burning at the base and the bark was burned off in some instances to quite an extent. One limb that had been in contact with the negative feed wire was found dead, but the tissue at the base of the trunk was normal. Dr. J. W. Toumey, director of the Yale Forestry School, who examined many of these trees, found a disintegration of the wire where it came into contact with the limbs, apparently due to electrolytic action, and chemical analysis showed the presence of copper and zinc in the tissues of the wood that had been in contact with the negative or overhead wire. Dr. Toumey believes that in such cases the disintegration of the copper wire and the absorption of the copper by the tissue were responsible for the death of the limbs. If true, this entirely new state of affairs would indicate that the electrical injury from direct currents not only arises from heat but also from the electrical disintegration of metals, which may poison the tissues. These observations demonstrate that we have a variety of conditions to deal with in considering the effect of direct current electricity on trees, and these phenomena may be summarized as follows: —

Burning and injury to plant tissue are much more noticeable at points with a positive potential[1] than at points with a negative potential.

When the rail is at a positive potential the overhead wire, which touches some part of the tree, is negative, and the bark and soil are saturated with moisture, and a circuit is formed by means of this surface moisture.

The moisture conditions and the electrical resistance, etc., at the base of the tree are different from those above, therefore a larger area of tissue is affected by the positively charged rail.

As the bark becomes heated through the film of water, the electrical resistance is reduced and the current increased to such an extent that the vital layer is destroyed.

The actual current passing through the inner tissues must necessarily be insignificant, and when there is a film of water on the bark, probably no current passes through the cambium; furthermore, the moist soil between the rail and the trunk of the tree becomes a better

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[1] Positive electro-static charges have a more stimulating effect on plants than negative charges, and retardation of growth and injury to the cells are more pronounced. The phenomena associated with the positive and negative galvanotropic bendings of roots may be explained in this way (24th Ann. Rept. Mass. Agr. Exp. Station, Pt. I., p. 144, 1912).

conductor for the current than the roots. The actual injury, therefore, is done by the current traversing the film of water rather than any of the inner tissues. The maximum heat and the areas most affected are near the base of the trunk.

In regard to the possibility of injury to large trees by direct currents passing directly through them, experiments show that what holds true for alternating currents is true also to a great extent of direct currents. However, it would require a voltage much higher than that furnished by most electric railways at the present time.

It might be possible for direct currents to produce a weakening effect on the vital activities of the tree, although not causing any perceptible burning. If, for example, a tree was subjected to a strength of current equivalent to that represented between R and MX in Fig. 3, page 2 (retardation current), there might occur a disintegration of the cell contents, causing the tissues to become abnormal and finally die, but the electrical resistance of trees is so great that a quite high potential would be necessary. If the potential of the electric railway systems were increased ten or twenty times it is possible that some injury might result to trees even under ordinary moisture conditions.

Probably the amount of ground leakage occurring through imperfect rail connections would not cause any perceptible injury to trees. Nor is there any direct evidence that lightning arrestors when placed near trees cause any injury by discharges. However, the guy wires used by electric railway systems are a source of danger from lightning, and we have observed cases where large limbs have been destroyed and the trunks of the tree badly lacerated by electrical discharges from these wires.

On the whole, the cases of death to trees from electricity are by no means so numerous as is generally believed. Because a large number of trees near electric roads, etc., often look sickly it must not be concluded that electricity is always the cause. In cities and towns, where most of these unhealthy specimens are found, there are innumerable destructive factors for trees to contend with. It is quite essential in diagnosis work, therefore, that all of these factors be taken into consideration before a definite opinion in regard to the cause of any abnormal condition is formed.

Electrolysis.

Direct current electricity is frequently responsible for electrolysis of gas and water mains, and lead coverings of underground telegraph circuits are often affected. The trouble is often so serious that the iron gas and water pipes (Fig. 9, Plate III.) become corroded and eaten with holes in a few weeks or months, causing leakage. When gas mains are affected by electrolysis, the gas escapes and permeates the soil, so

that electricity sometimes becomes a primary and gas a secondary factor in the death of trees.

The phenomena associated with electrolysis are often complex and difficult to do away with entirely, according to expert electricians, but much of the trouble can be eliminated by proper bonding of the rails of electric roads and the grounding of different systems.

Electrolysis is more common in wet than in dry soils. Cases are on record where severe electrolysis has taken place 700 or more feet from the source of leakage. It more often becomes troublesome in cities where numerous railways and public-service corporations of all kinds make use of the streets. We have observed cases where plants have been stimulated and their growth increased by escaping electricity in the soil.

Lightning.

The common effects of lightning strokes on trees are so well known that it is not necessary to dwell upon them here; but lightning does not always strike a tree in the same way, and the peculiar effects sometimes produced are often interesting. Very powerful discharges of lightning act somewhat like an avalanche, causing a severe shattering of the tissue, while less powerful discharges may remove a strip of wood only a few inches wide and 1 or 2 inches thick. Lightning often takes a spiral course, following the grain of the wood, which is sometimes very irregular. Even when strips of wood 4 or 5 inches wide and 2 or 3 inches thick are removed, in which case the electrical energy is enormous, the path of the discharge is shown only by a dark-colored streak 2 or 3 millimeters wide.

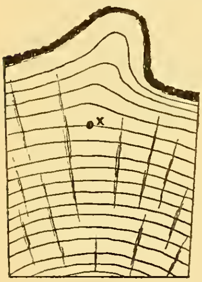

Fig. 11. — Cross-section of elm shown in Fig. 10; X = small dead area corresponding to path of lightning discharge.

Sometimes trees are killed outright by lightning without being shattered or displaying any other of the common effects. In such cases the discharge is apparently dispersed so as to cause no visible mechanical injury to the tree, but the girdling of a large or small area of the living zone or cambium layer of the trunk would be sufficient to cause its death. However, in a very large number of instances neither death nor mechanical injury of any importance takes place. Hundreds of trees are annually struck by lightning that never show any effects except to those capable of interpreting the small narrow ridges which later make their appearance on the trunk. (See Fig. 10, Plate V.). In such cases the lightning discharge follows the line of least resistance, — the cambium zone, — burning a small channel usually about 1 millimeter in diameter. The

tissues surrounding the channel are apparently not injured, but the annular rings which are later formed outside the burned channel are much broader, resulting in the formation of a ridge on the bark. (See Fig. 11.)

Earth Discharges.

There are many cases of lightning that are apparently earth discharges. Their effect on the tree is quite characteristic and not at all similar to the ordinary forms of lightning strokes. Our attention was called several years ago to some shade trees to which lightning had apparently caused some injury. These trees were maples 5 to 18 inches in diameter, growing in soil composed mainly of gravel containing oxide of iron, and underneath this a stratum of quicksand. A considerable number of the trees showed the effects of repeated earth discharges, in some cases becoming so disfigured that they had to be replaced for the third time. These discharges occur during thunder storms, and those who have observed them for many years relate that they give rise to a dull, characteristic report resembling that caused by throwing a wet cloth on a hard surface. The whole tree is not affected as a rule, as the lightning stroke seldom follows up the main trunk, but discharges at the points of several branches. As a rule, however, one side of the trunk and one or more of the limbs on that side are affected and the symmetry of the tree destroyed. The first indication of the discharge is shown by the immediate wilting and subsequent death of the leaves of the affected limbs, which also die later. In the course of time cracks similar to those caused by frost, and later, ridges due to healing, will be seen on the trunk, showing the path of the discharge, and occasionally when the injury is considerable the bark falls off near the affected part of the tree. The limbs, however, are not always killed, frequently splitting (see Fig. 12, Plate V.), and a cracking of the wood for some depth is now and then observed on the trunk and limbs along the path of discharge.

A very much larger number of trees show earth discharges than is realized. MacDougal[1] has called attention to some trees which appear to have been injured by earth discharges.

Whether the chemical composition of the soil has any particular bearing on earth discharges is not positively known. It is known, however, that there frequently exist great differences in the electrical potential between the earth and air during thunder storms, and that the electrical conditions of the atmosphere and earth may change instantly from negative to positive. Some observations made in our laboratory with a Thomson self-recording quadrant electrometer and

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[1] Journal of the N. Y. Bot. Gardens, Vol. III., No. 31, July, 1902.

water-dripping collector show that the electrical potential of the atmosphere varies from a negative charge of 75 volts to 300 positive at various times at a distance of 30 feet from the ground; and our records show that most of the time the atmosphere is charged positively. It is also known that trees occasionally discharge sparks at their apices, showing that insignificant earth discharges occur through trees; and when the soil in which potted plants are growing is charged electrostatically, small sparks are thrown off from the leaves. Earth discharges through trees, whether strong or weak, appear to be similar in nature, and may be associated with changes in the potential of the earth and atmosphere. The high electrical resistance shown by plants in general, as already stated, serves as a great protection against death from lightning and electric currents.

Susceptibility of Different Trees to Lightning Stroke.

There has always been great difference of opinion in regard to the susceptibility and non-susceptibility of various trees to lightning, and the data on the subject gathered from this and that source are altogether too meager to admit of reliable statistics. But it is known that the location of the tree, nature of the soil, elevation, etc., are of great importance in determining susceptibility to lightning.

It has already been pointed out that electrical resistance is influenced by temperature, and the percentage of moisture in the tissues is also an important factor. During thunder showers trees become more or less drenched with rain, and according to Stahl,[1] the more thoroughly wet the tree is the less susceptible it becomes to lightning stroke. He bases his observations on the fact that smooth-bark trees like the beech and others, which are considered more immune to lightning, become thoroughly wet during storms, while the oak and other rough-bark trees do not. Stahl's idea, therefore, is that smooth-bark trees possess a better water-conducting surface and have a tendency to equalize the electrical tension existing between the atmosphere and the ground, so that they are rendered less susceptible to lightning. His deductions were based upon experiments with electrical discharges made with the bark of different species of trees containing various percentages of moisture. He further observed that vertical limbs were more likely to become drenched than horizontal, and that the lenticels and stomata play a rôle in the equalization of the differences in electrical potential existing between the tissues and the atmosphere, etc. There appears to be no difference in the electrical potential under deciduous trees and in the open air when there is no foliage, at corresponding heights, and the electrical potential will average 40 per cent. less under the foliage of trees than in the open air when the foliage is developed.

[1] Stahl, E. Die Blitzgefährdung der verschiedenen Baumarten, Jena, G. Fisher, 1912.

The potential of the air is usually negative, although occasionally changing to positive. In the case of coniferous trees, however, like the Norway spruce,[1] we found that the potential under the foliage was invariably positive or similar to that of the earth, which may be explained on the theory that conifers are constantly discharging positive electricity to such an extent that the air surrounding them becomes charged similar to the earth. To what extent the film of water on the bark is capable of equalizing the difference in electrical potential in the air surrounding the trees, as well as the ground and in the tissues themselves, has not been wholly determined, but we had difficulty in obtaining potential readings under the foliage of elms in wet weather in our experiments covering two summers. This may in part be explained by the improper installation of our collector. It is not unlikely that the film of water on the bark of trees during such periods would have a tendency to affect materially the potential of the surrounding air, and possibly to equalize the electrical tension. The subject should have further investigation, but we believe that it is possible to protect trees from injury by lightning, whether they be atmospheric or earth discharges.

Methods of preventing Injury to Trees from Wires.

The constantly increasing use of electricity for various purposes makes necessary a more extensive use of wires which have become a great menace to shade trees. The appearance of streets is also hardly improved by the increased number of poles and wires, and the legal restrictions as to the height, distance apart, etc., of the wires of the telephone, telegraph, trolley and electric light companies make the problem of maintaining shade trees on the same street with public-service corporations a serious one. Of all the troubles with which tree wardens have to contend the wire problem is often regarded as the worst. Notwithstanding the strict laws which some States have adopted in regard to injuring shade trees, the agents of some public-service corporations often have little regard for trees or the laws respecting them. Where 40-foot poles must carry the wires of three or four public-service corporations there can be little or no opportunity to preserve the natural symmetry of shade trees, especially when low branching maples and other trees are planted on the same side of the street with the wires. There is less interference from limbs with low than with high-tension wires. Trees like the elm, whose branches form acute angles, offer less obstruction to wires than maples; but not all streets, of course, are planted with elms, which may be as well, considering their susceptibility to various pests and unfavorable climatic conditions.

The best solution of the wire problem lies in burying the wires. This

[1] Mass. (Hatch) Agr. Exp. Sta. Rept. 1905, p. 14.

has been done to quite an extent in large cities, especially in the business sections, the telephone corporations having adopted this system to a much greater extent than the electric light companies. It is an expensive system, however, and those who so strenuously advocate its adoption do not always consider that in the end it is the patrons who have to pay for it.

Another method of preventing wire injuries is the erection of high poles to bring the wires over the trees. This is sometimes done, especially where the trees are young or of a species that naturally grows low, when a very high pole would be sufficient to clear them for many years. The cable system may be used for telephone wires, and much injury to trees prevented. Large cables are rather expensive to install,

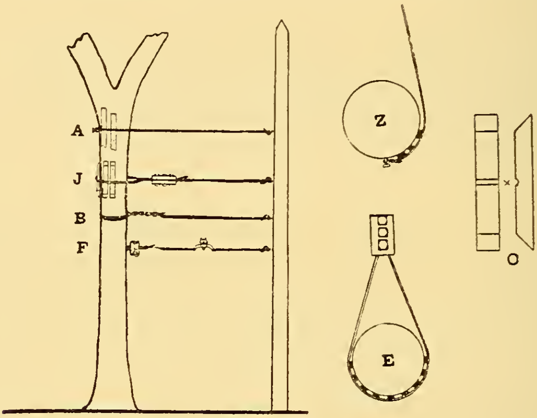

FIG. 13. — Showing different methods of attaching wires to trees: *a*, wire attached to lagbolt, and tree protected from it by wooden blocks; *z*, cross-section of same; *b*, wire loops placed tightly around tree, causing girdling; *f*, showing attachment of trolley guy wires; *j*, loose loop fastened with clamps and separated from tree by blocks; *e*, cross-section of same; *o*, creosoted oak blocks with groove *x* to support the wire.

but what is termed the "ring construction" system may be used to advantage in many instances, particularly in the suburbs. In this way it is possible to run a line through avenues of fine trees in the country districts without necessitating pruning or disfiguration.

Rights of way for poles on private property back of residences are sometimes secured, and by this means the poles and wires may be removed from the streets, much to the advantage of the trees. But such rights are often difficult to secure, and are not always satisfactory either to the public-service corporations or the owners of the property. The former naturally do not care much for these rights of way unless they are legal and permanent, and the owners in granting permanent

rights run a risk of lowering the value of the property. Most of the very high-tension transmission services, however, are at present on private property and seldom interfere with trees. High-tension lines are affected seriously merely by close proximity to trees; therefore these rights of way have to include broad strips of land, which of course is expensive.

On general principles it is not wise to allow wires to be attached to trees, although this is often done. Trolley and electric light wires are frequently guyed to trees, but they are a source of danger, since injury is likely to occur from the crossing of the wires, and lightning discharges occasionally pass from the wires to the tree, causing damage.

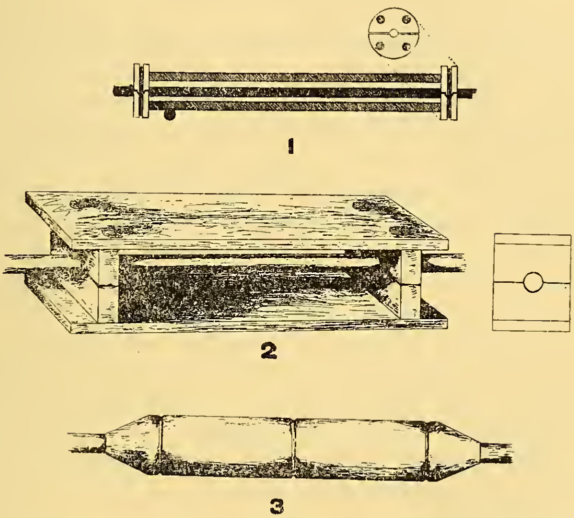

FIG. 14. — Showing different types of guards for electric wires: 1, porcelain dowel guard; 2, porcelain wood guard; 3, wooden sleeve.

It is, however, often better to allow this than to endure the erection of ugly poles; but proper insulation of the wires should be insisted on, although ordinary insulators have little effect on lightning discharges. The lagbolt system in common use for guying wires to trees is not the best method, for sooner or later the wire and bolt become imbedded in the tree and cause injury. Moreover, a direct metal connection with a tree is objectionable, as it has in more than one instance proved. The block system is better, although it may not in all cases be free from objections. In no case should a wire be allowed to pass tightly around a tree, as it will girdle it in time. When live wires come into contact with limbs, some type of insulator should be employed similar to that shown in 1, Fig. 14, of which there are various types, some being quite effective in preventing injury from low-voltage lines. The type shown

in Fig. 14, No. 2, is cumbersome and unsightly, but is one of the most effective. The principle of the porcelain and dowel insulator is good, but it has a tendency to slide on the wires and become displaced. If it were provided with larger dowels, and the danger of displacement on the wires done away with, it would prove much more satisfactory.

Wires often accidentally come into contact with trees by the displacement of poles, particularly on curves, where the strain is very great, but much of this injury may be prevented by imbedding the poles in Portland cement. It should be pointed out that the necessity for guying poles to trees may be obviated in this way.

Better methods of handling this vexatious question of wires and shade trees should be forthcoming in the future, and even at present there must be a compromise between the tree warden or city forester and the companies as to the best method of wiring through tree belts and the amount of pruning allowed. Conditions at present favor the corporations, as they are furnishing valuable and necessary facilities for business, etc., and in towns they obtain their franchises and location of poles from the selectmen with little difficulty. The selectmen notify the abutters of any contemplated installations of poles and wires or of changes to occur in the systems, and the abutters are given a hearing. However, they usually wake up to their duty only after the installation of the lines, when the tree warden must assume all responsibility for injury to the trees. He has to choose between two courses, — prevent the pruning or permit it. In either case the companies can erect the poles and install the wires, allowing the wires to burn their way through the trees, although this, of course, often causes trouble to the corporation as well as to the consumer. In case of injury to trees the warden has access to the courts, but most companies are willing to put up with a few moderate fines for the sake of the right of way through a tree belt.

Summary.

Electricity acts as a stimulus to plants. The minimum and optimum current strengths probably differ little in different plants. The maximum current, or that necessary to kill a plant, is quite variable.

Outside of the disfiguration to trees from pruning necessitated by wires, the greatest injury consists in the local burning and often partial destruction of the tree caused by high-tension line wires.

There is practically little or no leakage from wires during dry weather. In wet weather, however, when a film of water is formed on the bark, more or less leakage occurs, and if the insulation is insufficient, grounding takes place and burning, due to "arcing," results.

No authentic cases have been observed by us where the alternating or direct currents as ordinarily employed have killed trees; but instances are known in which the death of trees has taken place when

the polarity in electric railway systems have become reversed; *i.e.*, the rail becoming positive and the feed wire negative.

The burning is more pronounced at the positive electrode than at the negative, and when the current is reversed a larger area of tissue is affected. The burning arises from the heating of the film of water on the bark, which destroys the live tissue underneath.

The high resistance offered by trees and plants in general serves as a protection against severe injury from lightning and contact with high-tension line wires.

The least resistance in trees occurs in the vital layer (cambium) and adjacent tissues.

The electrical resistance of trees is influenced materially by temperature and moisture.

The physiological effect of the direct current on vegetable life differs from that of the alternating.

There is evidence to support the idea that a direct current of not sufficient strength to cause burning may electrolize the cell contents and later result in the death of the tree.

Earth discharges during thunder storms are more common than generally supposed, and are known to disfigure and cause the death of trees.

PLATE I.

FIG. 1.—Showing maple tree injured by lightning discharge from trolley guy wire, causing death of limb and laceration of trunk.

FIG. 2.—Showing the destructive effect on the growth of a maple tree of a mass of wires.

PLATE II.

FIG. 4.—Showing injury to young maple tree by linemen's spurs.

FIG. 5.—Showing the effects of strangulation by wires.

PLATE III.

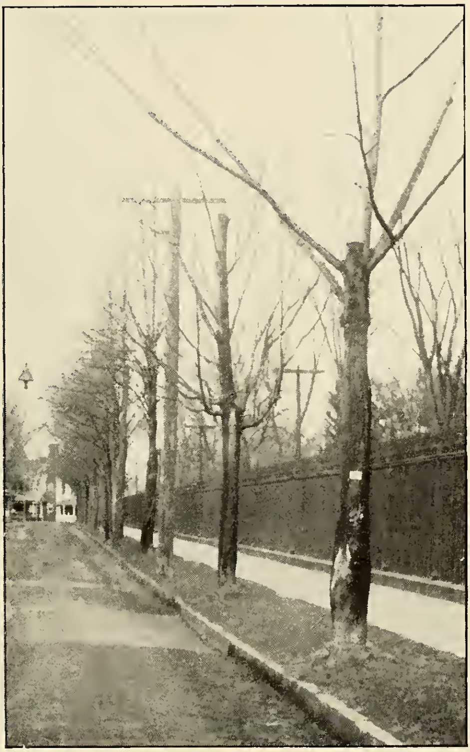

FIG. 6.—Showing disfigurement of trees caused by high-tension alternating current wires.

FIG. 9.—Showing electrolysis of gas pipes. (After A. A. Knudson, "Corrosion of Metals by Electrolysis.")

PLATE IV.

FIG. 7.—Showing deep burning of large limb by high-tension alternating current wire.

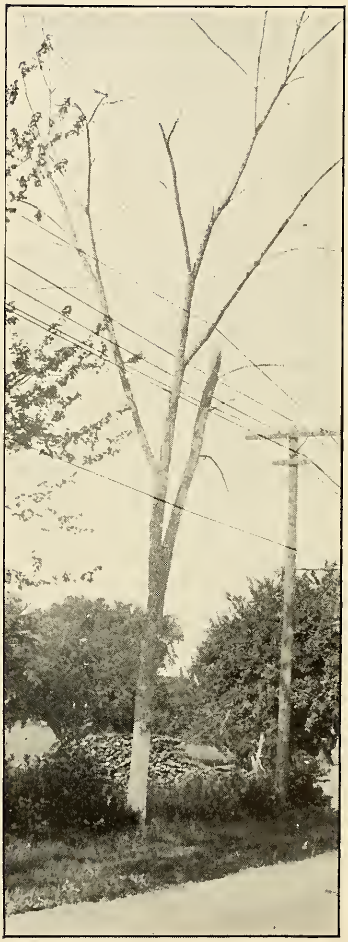

FIG. 8.—Showing elm tree killed by direct current (reversed polarity) from electric railway system. Note effects of burning at the base of the tree.

PLATE V.

FIG. 10.—Showing ridge on elm tree caused by feeble lightning discharge.

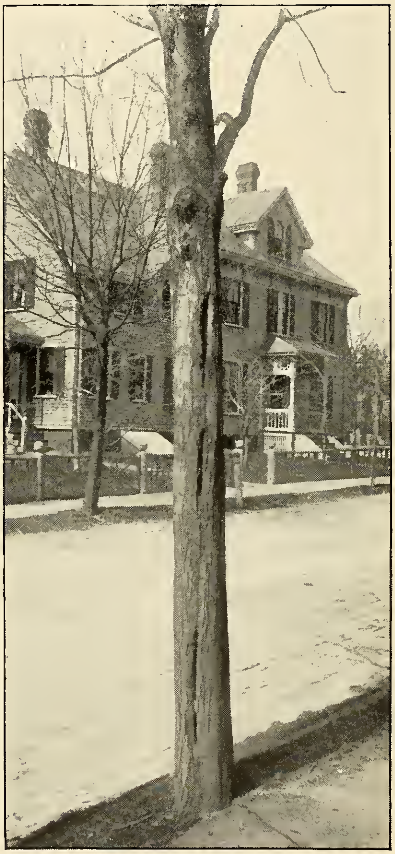

FIG. 12.—Maple showing effects of earth discharges (lightning), causing splitting of the trunk and death of limbs.

THE MARGUERITE FLY OR CHRYSANTHEMUM LEAF MINER.

(*Phytomyza chrysanthemi* Kowarz.) (Order, *Diptera;* Family, *Agromyzidæ.*)

M. T. SMULYAN, B.S. [1]

INTRODUCTION.

The growing of plants under glass is an important industry in Massachusetts, and is becoming more so every year. Among the plants which are of ornamental value, or are raised for their flowers, marguerites or daisies, chrysanthemums and other Compositæ are very generally grown, the two former often on a large scale. It is not at all surprising, then, that complaints are heard on all sides regarding the ravages of the Marguerite Fly, or Chrysanthemum Leaf Miner. Indeed, in many instances, the commercial growing of marguerites and some other Compositæ has been given up on account of this pest.

At the time the writer began the investigation of this troublesome insect it was not generally known that there were one or two florists in the State who possessed a satisfactory method for its control, though such was the fact.

The investigations upon which this paper is based were carried on in the insectary and laboratories of the Department of Entomology of the Massachusetts Agricultural College, Amherst, under the direction of Prof. H. T. Fernald and Dr. G. C. Crampton. The investigations were begun early in February, 1913, and continued to July of the same year, in connection with the marguerite, or cultivated daisy, as a food plant. Some additional data relating to the life history of the insect were collected during the following November. The thanks of the writer are due both to Professor Fernald and Dr. Crampton for their interest in the work, and for a number of valuable suggestions. The writer is also under obligations to Mr. Walker Holden of Andover for furnishing infested marguerites for study, and to the latter again and to Mr. W. R. Nicholson of Framingham for their readiness in answering questions, many of the answers proving very helpful.

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[1] Contribution from the entomological laboratory of the Massachusetts Agricultural College. Part of a thesis for Ph.D. degree.

The methods and appliances used in connection with the work are all very simple. The methods are described in the various sections which follow. The habits of the adults were studied very largely with the aid of an ordinary pocket lens while the flies were at large upon the host plants in the insectary. In the study of the other phenomena relating to the adults, cheesecloth bags possessing a certain degree of stiffness were found very useful. In the laboratory, for the study of the various stages, habits of the larva, etc., an ordinary compound microscope and a Zeiss-Greenough binocular were found indispensable.

The outlines of the drawings, except that of the adult, were all made by means of the camera lucida. The photographs were taken by T. W. Nicolet under the direction of the writer.

HISTORY AND DISTRIBUTION.

The Chrysanthemum Leaf Miner, Chrysanthemum Fly, Marguerite Leaf Miner, Marguerite Daisy Fly, or the Marguerite Fly, as the insect is variously called, was first detected in this country, according to Dr. Lintner (Fourth Report on the Injurious and Other Insects of the State of New York, 1888, p. 73) in October, 1886, in the greenhouse of Mr. Chas. A. Dana, near Glen Cove, N. Y. Dr. Lintner writes: "The leaves of some daisies (marguerites) were seen to show some wart-like specks and irregular, whitish, linear markings, and soon afterward to shrivel up and die. Examination for the cause disclosed very small 'worms' working within channels in the interior of the leaves." Some of the infested foliage was sent to Dr. Lintner in Albany the following February. The operations of the insect were first noticed by Mr. Wm. Falconer, head gardener at "Dosoris."

Mr. Falconer reported this discovery independently in the "American Florist," March 15, 1887 (Vol. II., p. 297). "This little pest," writes Mr. Falconer, "made its first appearance here last November." (There is a slight discrepancy between the statements of Dr. Lintner and Mr. Falconer regarding the first appearance of the fly in the greenhouse; according to Dr. Lintner it was October.) "Before then I was not aware of its presence in this country, but since then I find it as abundant in greenhouses at Glen Cove Landing and at Hinsdale as it is here." (Mr. Falconer, like some others at the time, thought the insect a European species.) "I first observed its presence by noticing little wart-like specks and irregular, whitish, line-like markings on the leaves of some of the marguerites, and these traces soon multiplied exceedingly and the much-affected leaves withered up and died. The fly is a small insect and might readily be mistaken for one of the little flies so abundant about fermenting horse manure. When disturbed it 'hops' about rather lazily or flies from one branch to another, but seldom flies away more than a few feet. It lays its eggs singly under the skin of the leaf, the wart-like specks forming over the eggs. In a few days' time the little white grubs are hatched; these are the evil workers. They devour the fleshy substance between

the skins of the leaf, eating their way in irregular lines or broad patches, and these are the whitish markings observable on the surface of the leaf. After two weeks of energetic eating it thrusts its head outside of the skin of the leaf and pupates. From the laying of the egg till the perfect insect issues from the chrysalis is within five weeks."

Dr. Lintner (Fourth Report on the Injurious and Other Insects of the State of New York, 1888, p. 76) mentions Queens, Long Island, as another locality where the insect was present at about the same time it was operating at Glen Cove Landing and Hinsdale.

The depredations of the fly seem to have been noticed elsewhere in New York about the same time, infested chrysanthemum leaves having been received from Mr. Charles Anderson of New York by the Department of Agriculture at Washington, Dec. 30, 1886. (Coquillett, Insect Life, VII., 1894–95, p. 399.)

Two weeks later, Jan. 14, 1887, infested marguerite leaves were received by the Department of Agriculture at Washington from Prof. Thomas Meehan of Germantown, Pa.

In 1889 the insect was found mining in the leaves of Japanese chrysanthemums (in the Arnold Arboretum?), near Boston, Mass. (F. J. Jack, Garden and Forest, III., 1890, p. 440), and according to Mr. Jack it had been troublesome in other places in the vicinity of Boston, mining in the leaves of chrysanthemums, eupatoriums and cinerarias in greenhouses. (Lintner, Seventh Report on the Injurious and Other Insects of the State of New York, 1891, pp. 244, 245.)

In 1890 infested marguerite and feverfew leaves were received by the Federal Department of Agriculture from Irvington, N. Y., Danbury, Conn., and Brooklyn, N. Y. (Coquillett, Insect Life, VII., 1894–95, p. 400.)

In February, 1893, infested cineraria leaves were received by Dr. Lintner from the greenhouses of St. Vincent's Male Orphan Asylum, Albany, N. Y. (Tenth Report on the Injurious and Other Insects of the State of New York, 1895, p. 510.)

In April, 1907, Mr. C. W. Johnson of the Boston Museum of Natural History received specimens of the adult fly for identification from Prof. E. D. Sanderson of New Hampshire, indicating that it was causing trouble in that State about that time.

In 1911 it was reported in Connecticut again. (Britton, Eleventh Report of the State Entomologist, 1911, p. 342.)

In 1912 it was discovered mining marguerites in a greenhouse in Helena, Mont. (Cooley, Tenth Annual Report of the State Entomologist, Bull. No. 92, November, 1912, p. 56.)

During the spring and summer of the same year a very serious outbreak occurred in some greenhouses in Milwaukee, Wis., which had imported infested chrysanthemums and marguerites from Boston, Mass. It was also reported from Chicago "and other parts." (Sanders, Journal of Economic Entomology, Vol. V., No. 6, December, 1912, p. 472.)

Since 1899, no data being available previous to that year, at least five complaints have been received from various parts of Massachusetts by Dr. H. T. Fernald, Entomologist for the Massachusetts Agricultural Experiment Station. The last complaint was made in January, 1913, by Mr. Walker Holden of Andover, and led to the investigation of the pest by the writer. Replies to inquiries made during the summer and fall, however, indicate that the pest is generally distributed throughout the eastern part of the State.

FOOD PLANTS.

Falconer, in his account of the insect in the "American Florist," states that while the marguerite (*Chrysanthemum frutescens*) seems to be its favorite food, it does not at all restrict itself to this plant, but attacks every other plant of the family Compositæ within reach. It appeared to Mr. Falconer that it even preferred the double white feverfew (*Chrysanthemum parthenium*) to the marguerite. He mentions *eupatoriums, gazanias, Helianthus decapetalus* var. *multiflorus*, and *Senecio* (*Cineraria*) *cruentus* as also having been attacked. Dr. Lintner received from the same greenhouse infested leaves of the tansy (*Tanacetum vulgare*) and of three other Composite species which he did not identify. As already stated, the common greenhouse chrysanthemum (*Chrysanthemum indicum, C. morifolium* or *C. sinense*) was very early noticed as a food plant. This completes the list of food plants recorded, so far as the writer has observed.

During the writer's investigations, however, adult flies were reared from a number of additional species of plants of the family Compositæ. These plants, though growing in the greenhouse, are not normally greenhouse plants, but had (with the exception of one, — *Helianthus annuus*, the common annual sunflower, which was growing in the greenhouse of the Department of Botany, and was found infested the following fall) simply been allowed to grow, together with a number of other weeds, in the hope that new food plants might perhaps be discovered. These plants are *Solidago nemoralis*, goldenrod; *Ambrosia artemisiifolia*, ragweed; hogweed, etc.; *Taraxacum officinale*, dandelion; *Bidens frondosa*, beggar ticks; *Daucus carota*, wild carrot; *Chrysanthemum leucanthemum*, the common white or ox-eye daisy; and *Antennaria plantaginifolia*, everlasting or ladies' tobacco.[1]

The discovery of the above food plants suggested that the pest could lead an outdoor existence, even in absence of its cultivated food plants, and, surely enough, during the last days of April some dandelions growing at the foot of the greenhouse were found infested.

The flies apparently did not venture from the immediate vicinity of the house. Only the plants at the foot of the house were attacked, and numerous observations which continued into late June failed to disclose

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[1] These plants were kindly identified by Mr. Geo. H. Chapman and Prof. A. V. Osmun of the Department of Botany.

others infested. The following December, however, the writer discovered the flies in the greenhouses of the botanical and floricultural departments, somewhat removed from the insectary, where they had been attacking for some time sunflowers, marguerites and cinerarias.

Falconer's observations, to the effect that the insect shows a strong partiality for marguerites, seem to have been correct. Chrysanthemums in close proximity to the marguerites in the insectary were only very slightly attacked. A very strong inclination was manifested for the dandelion, goldenrod, ragweed, and ox-eye daisy, however. These were badly injured and were much preferred to the white marguerites; indeed, after these plants became numerous and large, the white marguerites were almost entirely neglected. The yellow marguerites, on the other hand, remained favorites, and continued to be badly infested.

NAME.

In the earliest published report on this insect by Falconer in the "American Florist," it was designated *Phytomyza affinis* Fallen, the name having been taken from a species which was doing similar injury to plants in Europe, and which now occurs in North America.

Dr. Lintner, however, obtaining specimens of this insect and finding it unknown to him, submitted the adult fly, together with its pupæ and larval mines, to Baron Osten Sacken, who identified it as the European species *Phytomyza lateralis* Fallen. It was thus designated by Dr. Lintner in his report on this insect in his fourth annual report.

Somewhat later, other specimens found mining chrysanthemums and other plants in the vicinity of Boston by Mr. J. G. Jack, and believed by him to be *Phytomyza nigricornis* Macquart, were forwarded by Mr. Jack to Baron Osten Sacken for determination. On examination these were found to be the same as those previously submitted by Dr. Lintner and which were identified as *Phytomyza lateralis* Fallen; but as they did not correspond with *P. lateralis*, Osten Sacken realized the mistake he had made and lost no time in notifying (early in 1890) Dr. Lintner, writing in part, as follows: —

> I am very sorry to acknowledge that I must have misled you in this case by a wrong determination. I do not remember now under what circumstances I committed the blunder and what prevented me from sending the specimens to Kowarz.

The examples from Mr. Jack were then sent by Osten Sacken to Kowarz. Unable to identify the insect with any known European species, Mr. Kowarz described it as a species new to science, and named it *Phytomyza chrysanthemi*. The description, translated by Osten Sacken, was first published in this country in Dr. Lintner's "Seventh Report on the Injurious and Other Insects of the State of New York," 1891, p. 243.

Aldrich in his "Catalogue of North American Diptera" (1905) lists it as *Napomyza chrysanthemi* Kowarz (*Napomyza* originally a subgenus of

Phytomyza, but now raised to generic rank by some writers), but this is clearly an error, as the keys in the literature referred to in the catalogue place the insect in the older genus *Phytomyza*, the posterior cross vein being absent in *chrysanthemi*.

Sanders (Journal of Economic Entomology, Vol. V., No. 6, December, 1912, p. 472) has already referred to the insect by this catalogue name.

INJURIES.

(Plates II. and III., Figs. 9, 10, 12.)

The first indications of the activity of the insect are seen in minute, pale specks, blotch-like, and usually fan-shaped, on both surfaces of the leaves (Fig. 9). As a rule, they are more numerous on the upper side. These specks or blotches are produced by the adult female fly, which pierces the epidermis and destroys the parenchyma beneath by means of her ovipositor, for the purpose of feeding or egg laying.

These blotches, however, do not long retain their original appearance. In a few days, as a result of a reaction on the part of the injured parenchyma, they usually develop into wart-like protuberances or papillæ (Fig. 9); and when the flies are abundant, during a period of great activity, the surfaces of the leaves may be literally covered with the papillæ, or papillæ and blotches together. On the other host plants which were kept under observation in the insectary the papillæ developed less readily, and as a rule, less perfectly.

The real damage, however, is caused by the larva or maggot. Seemingly possessed of a tireless energy and of appetites which never seem to be satisfied, the maggots move slowly along beneath the epidermis (most of the feeding is done immediately beneath the epidermis of the upper surface) of the leaf, devouring the parenchyma in their course, and leaving a whitish and usually irregular path — the external evidence of the mine which lies directly beneath — in their wake, the white color of which contrasts sharply with the green color of the rest of the leaf surface (Fig. 10). The mine widens and becomes more distinct as the larva increases in size. The part of the leaf thus mined (the petiole very often also), or the whole, if it is badly attacked, gradually dries up, and in this withered condition remains clinging to the plant (Fig. 12). Small plants may be killed in a comparatively short time during a period of great activity of the flies.

In reply to some questions of the writer in regard to the resulting injury, Mr. Walker Holden, who kindly furnished the infested marguerites for study, states that "the infestation reduces the number of flowers and weakens the plants to a very great extent." Moreover, he is of the opinion that, because of the reduced vigor of the plants, there is a tendency towards a reduction in the size of the flowers.

Of the plants (feverfews, yellow marguerites, and white marguerites) attacked in Mr. Holden's greenhouse, the yellow marguerites were the most seriously affected — so seriously that he destroyed them. Of the

two yellow marguerite plants kept under observation in the insectary, one did not bloom until June (the plants were received early in February), when the flies in the house had decreased and the attack had considerably abated, while the other produced no flowers at all — at least up to July 5, when the writer left Amherst for the summer. Buds in many instances formed, but they dried up after reaching a certain size. The following December the two yellow marguerite plants were dead.

IMPORTANCE OF THE PEST.

The wide distribution of the insect, the large number of commercially grown plants it attacks, the numerous complaints, — many of these reporting serious injury, — all attest and bear testimony to the seriousness of its depredations.

As far back as 1890, Mr. J. H. Ives of Danbury, Conn., writing to Coquillett of the federal division of entomology, stated that he would be compelled to abandon the growing of such plants as marguerites and feverfews, owing to the attack of this pest.

According to Britton (1911) the damage in Connecticut has been so great in some instances that the growers had to abandon the commercial growing of such plants as chrysanthemums, marguerites, feverfews, cinerarias, eupatoriums and tansies.

Sanders (1912), in reporting an outbreak in Wisconsin, states that the growers were facing an entire loss of their flowering plants caused by a complete infestation of the leaves.

Mr. Walker Holden, in reply to a letter of the writer, closes as follows: "I shall be very glad to help out in any way I can to conquer this pest, for it is surely a pest."

Fortunately, no great fears, it seems, need be entertained in regard to the insect as an outdoor pest, it appearing to be essentially an indoor or greenhouse insect. If provided with food, it will remain in the greenhouse all summer, although in reduced numbers. In addition to its being essentially a greenhouse pest, it is apparently also essentially a moderate-temperature insect, seeming to find its most congenial conditions in a temperate and somewhat humid atmosphere. The writer had noticed a considerable falling off in its numbers even before he left Amherst for the summer (first week in July). This could not be explained entirely on the ground that some had left the insectary to take up an outdoor existence, for those that left apparently remained in the vicinity of the insectary, and their numbers could therefore be observed. The hot, sunny, dry atmosphere in the insectary, it seems, is a much better explanation of the decrease. Such an environment may cause itself to be felt in a number of ways. It may diminish the egg-laying powers of the female; it may cause a reduction in the percentage of eggs hatching; it may cause the death of certain larvæ (the writer found both eggs that failed to hatch and dead larvæ in a number of instances in late June), etc. It is

quite likely that the numbers of the insect are reduced in a measure in all these ways. The fact that the insect has not been reported as an outdoor pest throughout all these years is very strong additional evidence that it is only a greenhouse pest.

LIFE HISTORY AND HABITS.

The Adult. (Plate I., Figs. 1, 2.)

Description.

The following description, taken from Dr. Lintner's "Seventh Report on the Injurious and Other Insects of the State of New York," 1891, p. 243, is Kowarz's original description of the insect, made from twenty specimens which were submitted to him by Osten Sacken in 1890, and published for the first time in this country in the above report: —

Front and face yellow, occiput gray, antennæ altogether black, tip of the palpi generally dark, oral bristles distinct, genæ narrow, hardly equal to one-third of the height of the eye. Thorax and scutellum uniformly gray, sometimes the former with a pale-yellow lateral stripe in front of the root of the wings; thoracic dorsum usually with four pairs of dorsal macrochetæ, but without the intermediate acrostichal [or inner row of the dorso-central] bristles; seldom a few in the vicinity of the scutellum; scutellum with four macrochetæ on the edge. Wings almost hyaline; veins blackish, yellowish near the root; the costal vein reaches the tip of the third vein only, which tip is rather far distant from the tip of the wing; the first, second, and third veins are distinct, the other longitudinal veins are thin, especially the fourth, which ends in the tip of the wing; the sixth vein is incomplete; the posterior cross vein is wanting; tegulæ and halteres pale yellow. Legs black only the knees pale yellow; sometimes also the trochanters of the fore legs yellow. Abdomen black, but little shining, the ventral sides more or less distinctly pale yellow; the posterior edge of the anterior segments with an exceedingly narrow pale-yellow margin; on the last segment this margin is more distinct. Genitals black, those of the male of moderate size; the ovipositor of the female hardly as long as the last abdominal segment.

The following additional minor observations may be appended: eyes red when insect is alive, black when dead; wings somewhat iridescent; the yellow on the ventral sides of the abdomen gradually narrowing from base to apex. Whereas the abdomen in the male tapers gradually and ends bluntly, that of the female ends somewhat pointedly, the last segment having the shape of a truncated cone. Length of body of male 2 millimeters, female slightly larger; this somewhat larger size of the female is especially marked during the egg-laying period.

According to Kowarz this species bears a close resemblance to *Phytomyza affinis* Fallen, but differs from the latter in the absence of the acrostichal bristles and in the shorter ovipositor.

Habits of the Adult.

In common with many other Diptera or flies, the marguerite flies lack the power of strong and long-sustained flight. They crawl lazily about, or make their way from leaf to leaf and from plant to plant in a skipping

or hopping flight, very seldom flying more than a few feet at a time. The periods between flights may be quite long, unless the flies are disturbed, and great portions of these periods may be spent at rest in one place. The males are, as a rule, more active than the females, the latter being also more tame.

Their activity and degree of tameness vary, also, with the time of day, with the degree of sunlight and with the temperature. They are comparatively tame in the early forenoon, late afternoon and on cloudy days. Inactivity and drowsiness, as might be expected, are strongly marked at lower temperatures. Both males and females are tame while mating and after, although the female remains thus for a much longer period.

While inactive in darkness they at once become active when brought into bright artificial light. They have been observed to mate in such light, and as will be seen later, will even oviposit.

Both sexes are strongly negatively geotropic, seeking, as a rule, the highest point of an object or vessel in which they are confined, a trait which was found very useful, and of which full advantage was taken by the writer during the investigations.

Mating.

Newly emerged flies kept in confinement in the laboratory, to determine how soon after emergence mating begins, yielded rather widely variable results; that is, there was a wide variation in the length of time elapsing between emergence and coupling for different individuals. While most of the individuals which were confined together for this purpose were of about the same age, some were of different ages, the age varying with the one or the other sex. These periods between emergence and mating ranged from approximately six to approximately forty hours, and were more or less scattered between the two extremes. Under natural conditions, with the flies free and at large on plants, the results would probably be modified. For instance, it is doubtful if under natural and normal conditions, with both sexes in abundance, individuals would abstain from mating for so long a period after emergence as did some in confinement in the laboratory. On the other hand, the fact that some united about six hours after emergence, would seem to indicate that in some instances, at least, mating takes place very shortly after emergence.

The length of time that couples remain united also varies. In one instance a couple remained attached for three and one-half hours, in another, two and three-quarters hours, and in another two hours. The more usual period, however, seems to be from one-half to one hour. As compared with the same in other Diptera or flies, this is rather short. The "northern cherry fruit flies," for instance, according to J. F. Illingworth, may remain coupled for eighteen and one-half hours. (Bull. No. 325, Cornell University, 1912.)

The male mounts the female, as a rule, when the female is at rest, by grasping her with his anterior legs and pulling himself up on her back.

He usually draws near gradually, by successive stages, stealthily. Quite a time is spent in covering the short distance, often too much it would seem, for very frequently the female will walk off or fly away before he reaches her. Sometimes, however, he will draw near at once, and, after a period of variable length of almost perfect quiet, will mount her in the usual way, or land on her back, apparently, by means of a well-calculated leap or jump. Not infrequently he may endeavor to mount the female while the latter is engaged in piercing the epidermis of the leaf for feeding purposes.

The sight of a couple in copulation excites the male quickly. It is not unusual to see two males upon one female, and as many as four have been observed. In one instance, in confinement, a male was observed trying to mate with a dead female, lying near by, on being shaken off by a couple already united.

That the instinct for mating is very strongly developed in the males was evidenced by their attempts, when confined together by themselves, without previously having had access to females, to mate with each other. In such cases one male would yield to the other just like a female.

When connected, the male rests upon the back of the female, his anterior legs grasping her thorax on top between the bases of the wings; the wings are spread apart just enough to accommodate the male. His intermediate legs grasp the sides of her abdomen about in the middle, or more usually, somewhat posterior to the middle, the posterior legs grasping the sides of the abdomen at some point beyond. The abdomen of the male curves downward and slightly forward to meet the genital opening of the female, and the last abdominal segment of the latter is normally raised somewhat above its usual level, due to the insertion of the copulatory organ of the male.

During copulation the female with the male upon her back stands quietly in one place, apparently, moving only when disturbed or when she is desirous of ridding herself of him. In the latter case, she is usually very restless, moving about continually, and in addition, endeavoring with great energy to kick him off. The male is perfectly quiet, excepting that now and then he may raise himself slightly and shake himself very violently, as if desiring to break loose.

On separating, the male immediately or soon after flies away. The female, on the other hand, remains quietly in place, or she may move to another part of the leaf and then come to rest. Immediately after, or after a short period of inactivity, she begins to protrude and retract her ovipositor in quick succession, repeating this, as a rule, a number of times, at irregular intervals.

She then engages in what seems like a cleaning operation, brushing the apex of her abdomen with her hind legs, and in turn rubbing these legs against each other and against the wings, the two legs against one wing, the wing being held between them, and each one against the wing on

its own side. It should be added, however, that the flies will often engage in this operation at other times than soon after mating.

Mating takes place, as a rule, in the forenoon — becoming less frequent towards noon — and during the latter part of the afternoon. Mating between about noon and the latter part of the afternoon is not very common on days of bright sunlight. On cloudy days it continues uninterruptedly.

As has already been intimated, couples isolated on leaves on plants in the laboratory were observed mating in artificial light.

As might be expected, the males are polygamous and the females polyandrous; that is, a male will fertilize more than one female, and a female will accept more than one male. The number of matings during adult life is probably large, and continues, it would seem, throughout the greater part of the same. A female confined with one male at a time within a cheesecloth bag upon a leaf on a plant accepted two males four times in three days, one of the males twice in as many days, and the other twice in one day. In another instance, a couple which had separated at 9.40 A.M. were coupled again at 2.40 P.M. of the same day, although during this second coupling the female was very restless, moving about considerably, as if she was not at all contented to receive him. As regards how long mating continues, there is a record of a female which emerged April 13 receiving a male May 22, forty days after emergence and seven days before her death; in another instance, a female which emerged April 10 was observed mating May 13, thirty-four days after her emergence and six days before her death.

Feeding.

The females, at least, feed during their adult life, the food being the juices of the leaves of the host plants. To this end the epidermis of the leaf is pierced and the parenchyma in contact with it at that point is cut or macerated by means of the tubular ovipositor.

The process forms a prominent feature of the female's activity, and is an interesting one to watch. Having selected the site — she often tests the leaf surface with the ovipositor — and placing herself lengthwise upon the leaf or leaf-lobe, so that her longitudinal axis is parallel with the longitudinal axis of the leaf or leaf-lobe, she flexes the apical portion of her abdomen downward and forward so that it approaches the leaf surface vertically. The epidermis is then pierced, and the ovipositor, which is but slightly exserted while it pierces the epidermis, is inserted into the leaf horizontally. Then, by means of a series of motions of the ovipositor in longitudinal, diagonal, and sometimes transverse directions, involving the alternate protrusion and partial retraction of the ovipositor, and accompanied by a rotary motion of the abdomen, the parenchyma in contact with the epidermis is cut or macerated. The apical portion of the abdomen is, as a rule, angulated somewhat during the latter part of the operation.

Following the withdrawal of the ovipositor, she backs up, and, applying her proboscis to the aperture previously made, feeds on the juices of the tissue thus exposed, protruding and retracting her ovipositor several times while so engaged. Towards the last of the feeding the proboscis is applied intermittently. The blind end of the incision made is almost invariably directed towards the apex of the leaf or leaf-lobe.

The length of time spent in the process varies. A large number of observations showed a variation of from twenty to one hundred and forty seconds for the piercing and cutting operation, although the more usual was from thirty to sixty seconds, and a variation of from six to one hundred and twenty-nine seconds for actual feeding, the more usual period being from about twenty to forty seconds.

The immediate apparent effect of the piercing of the epidermis by the female and her subsequent cutting directly beneath it is a very small, pale and usually fan-shaped blotch with a minute aperture in its periphery at the point where the handle of the fan would be located. This blotch, which measures roughly from $\frac{1}{2}$ to $\frac{3}{4}$ millimeter by $\frac{1}{2}$ to nearly 1 millimeter, but usually $\frac{1}{2}$ by $\frac{3}{4}$ millimeter, represents the area of the epidermis cut away from the parenchyma. Its paleness, which contrasts with the green color of the rest of the leaf surface, is due to the maceration or destruction of the green chlorophyllous tissue beneath, which imparts the green color to the colorless and closely applied overlying epidermis.

As pointed out once before, these blotches, with the exception of a few, do not retain their blotch-like appearance. Reacting to the injury, the leaf tissue at that point is stimulated to new growth, and, growing outwardly, away from the center, gradually undergrows the elastic epidermal area or blotch and raises it above its normal level, forming a wart-like tubercle or papilla with a single perforation at a point in its periphery. (Plate II., Fig. 9.) On the other host plants under observation in the insectary these papillæ formed less readily and less perfectly.

Feeding is done to a greater extent from the upper surface of the leaf.

Do the males feed upon the juices of the leaf tissue of the host plants as do the females?

Lacking the ovipositor with which the females are provided, the males are of course unable to pierce the epidermis of the leaf. In order, therefore, to feed upon the juices of the leaf tissue they must resort to the punctures made by the females. This, it should be said, the writer has not observed them doing. Experimental evidence, however, as will be seen below, though somewhat contradictory, would seem to indicate that they do.*

Thus males live longer when confined with females upon leaves on plants which are pierced by the females for feeding purposes than when isolated by themselves, under the same conditions, on leaves which remain entire on account of the inability of the males to pierce them. The length of life of a large number of males isolated by themselves on leaves within

cheesecloth bags was from two to five days, although a single individual lived seven days. On the other hand, males confined with females under the same conditions lived from four to thirty days, the greater number living considerably longer than five days.

To determine whether this longer period of life was due to feeding or to possible psychological influence or physiological effects following mating, males were isolated upon leaves upon which females had previously been confined and which leaves had been pierced by them. The males were thus afforded an opportunity to feed without being subjected at the same time to possible influences above mentioned, due to the presence of the females. Again, in order that they might have a condition approximating to that when free and at large upon the plants in the greenhouse — leaves with both old and new scabs — each series of males and females was alternated between the leaves, upon which they were respectively isolated at frequent intervals. Of the 19 males kept under these conditions only 3 lived considerably longer (eleven, twelve and thirteen days, respectively) than those kept by themselves on the unpunctured leaves.

On the other hand, of the 43 males confined with females of various ages in glass jars in absence of all food, the females being replaced daily or every other day, and mating observed in many instances, the usual longevity (if a single individual which lived four days is excepted) was three days.

Oviposition.

The details of the egg-laying process are practically a repetition of those of the feeding process. It differs from the latter process only in one essential particular, viz., the deposition of a single egg in the horizontal incision, in immediate contact with the epidermis of the leaf, just before the ovipositor is withdrawn. The tissue in contact with the epidermis having been sufficiently cut or macerated, the ovipositor is partially retracted for a few seconds, then protruded for a final and last time (often twice), the egg being deposited at the same time. The time spent in piercing and cutting the tissue in oviposition, in the instances observed by the writer, varied from twenty to forty-five seconds, and the subsequent feeding, from five to thirty-eight seconds. Only in a single instance did a female fail to feed after the deposition of the egg. The eggs are, as a rule, deposited from the lower surface of the leaf, and can be seen through the epidermis with the aid of a hand lens when the light is favorable. As a rule, the young leaves at the apex of a branch, or shoot, are not oviposited in, although they may be pierced for feeding purposes. The latter part of the afternoon appears to be a favorite time for oviposition.

Dr. Britton (Eleventh Report of the State Entomologist of Connecticut, 1911, p. 342) states that "the eggs are laid in or on the underside of the leaves." The writer has found only one egg deposited on the surface (lower surface) of the leaf during his investigations, and he regards the phenomenon as abnormal, as the larva, as will be seen below, is unable to

rupture the epidermis of the leaf and start a mine, and, when exposed on the surface of the leaf by being taken out of the mine, or by rupturing the epidermis which shields it, soon perishes.

Oviposition in Artificial Light.

While engaged in making an observation one evening on some adults confined upon a leaf within a cheesecloth bag on a plant in the laboratory, the writer noticed a female in the act of piercing the epidermis of the leaf. Whether this was done for the purpose of merely feeding, or for ovipositing, he was unable to say. To determine whether fertilized females would oviposit in artificial light, two fertilized females were isolated in the evening on a leaf within a cheesecloth bag on a plant placed in a darkened room. The leaf on which these females were confined was exposed to a fairly strong light, being about 15 inches from a 32 candle-power Mazda lamp. At this distance the leaf seemed to be — as perceived by the palm of the hand — just out of the higher temperature zone formed by the radiation of the lamp. Also, the leaf was so placed as to receive a uniform amount of light on its two surfaces.

The flies were removed from the leaf early next morning, having been on it for a period of ten hours. On examination it was found that oviposition had taken place. Twenty-four larvæ were subsequently counted.

Oviposition in Absence of Light or Total Darkness.

In this case five females that were caught at large on plants in the insectary in the forenoon (four of these were taken as they disengaged from mating) were isolated in the evening on a leaf within a cheesecloth bag on a plant placed in a dark room. In addition, the portion of the plant bearing that leaf was covered with a black cloth bag impervious to light. The flies were removed early next morning, after being on the leaf for nearly eleven hours. On examination, eggs were found to have been deposited. Eight larvæ hatched.

Assuming that the number of larvæ hatched in this experiment, as well as in the preceding one, represents the number of eggs laid in each, it is at once apparent that the number of eggs laid per female by the five females in absence of light was much smaller than the number laid per female by the two females in artificial light, the proportion being 1.6:12. Also, it should be borne in mind, that as the five females were taken in the morning and were not placed on the leaf until evening, they had neither the opportunity to feed nor to oviposit for a period of about ten hours previous to being placed on the leaf. These facts, in conjunction with their usual inactivity in darkness under normal conditions, leads the writer to believe that under normal and natural conditions oviposition in absence of light does not take place, and that the few eggs laid by the females in the experiment were due in all probability to the abnormal conditions to which these females were subjected previous to their isolation on the leaf.

Again, it is possible that some of the eggs were deposited while the flies

were being placed on the leaf by artificial light, although it was endeavored to keep them from doing so by keeping the leaf in constant agitation. At any rate, all the eggs could not have been deposited within that short time.

However, the fact remains that absence of light or total darkness is not necessarily an absolute bar to oviposition.

Oviposition — how soon after Emergence.

To determine how soon after emergence egg-laying begins, virgin females soon after their emergence were confined with males until they mated. Immediately following mating, each female was isolated on leaves on a plant in the laboratory, being shifted from leaf to leaf at regular and short intervals. One of these females laid her first eggs (fertile eggs) between twenty-five and thirty-six hours after emergence and between seventeen and twenty-eight hours after fertilization; another between thirty-one and forty-three hours after emergence and between two and three hours after fertilization; another between thirty-one and thirty-six hours after emergence and between twenty-two and twenty-five hours after fertilization. The rather wide limits are due to the limits of the period during which each female emerged, and which necessarily has to be embraced. It would seem, then, if these three females can be taken as criteria, that the first eggs are deposited on the second day of adult life or the second day after emergence, in the laboratory, at least.

Length of Egg-laying Period.

To learn how long females continue ovipositing, newly emerged virgin females were confined with males within cheesecloth bags on leaves on plants in the laboratory. New males were introduced from time to time to take the place of those dying, the females never being without males for any great length of time. These flies were shifted periodically, daily, or every other day, from one leaf to another, throughout the lifetime of the females. After the flies were removed the leaves were examined with a pocket lens, but the presence of larvæ within the leaves was surest proof that eggs were deposited.

One female, in March and April, which lived for twenty-one days, continued ovipositing to within three days of her death, the last eggs being deposited on the eighteenth day. Another female, in March, which also lived twenty-one days, continued to oviposit to within six days of her death, depositing the last eggs on the fifteenth day. Another one, also in March, which was confined with males upon a plant in a cage in the insectary for the purpose of ascertaining the number of eggs a female deposits during her lifetime, oviposited for the last time, as closely as could be calculated, on the sixteenth day of her adult life. Just when this female died is not known. Still another female, in May (latter part), which lived seventeen days, continued ovipositing to within one day of her death, depositing the last eggs on the sixteenth day.

Number of Eggs laid by a Female.

The above experiments for the determination of the length of the egg-laying period were used also as a means for ascertaining the number of eggs laid by a female during her lifetime.

As the marguerite leaves on which the flies were confined were not very large, and as a large number of eggs was laid during some of the periods during which each female was kept on a single leaf, it was not possible to count with any degree of accuracy the number of eggs laid during that period. Instead of the eggs, therefore, the larvæ were counted. The newly hatched larva, just as soon as it was recorded, was killed by being stabbed with a needle. It was thus prevented from obscuring and masking other larvæ by its mining. In this way, also, the possibility of its being counted more than once was obviated. But even with these precautions — owing to their escaping death — quite a number had to be denominated as doubtful.

The female, in March, which oviposited for sixteen days out of twenty-one which constituted her adult life, produced 141 larvæ. If 28 are subtracted from this number as having possibly been counted twice, she produced only 113. As this female was shifted from leaf to leaf daily, there is a record of the number of eggs laid every day during the entire period. The distribution was as follows: —

2 1 2 1 9 3 5 1 2 2 = 28
1–10–3–12–8–16–6–14–11–6–8–7–4–4–2–1 = 113

The upper series of figures represents the doubtful ones.

From this record it is seen that on the first day of the egg-laying period only one egg was deposited, and that similarly only one was laid on the last day; that the greatest number for a single day was deposited the sixth day; that there was in a general way a gradual decrease from the eleventh day to the last; that about two-thirds of the entire number were deposited during the first half of the period. Another interesting feature is seen in the alternation in the relative number of eggs laid, or the rise and fall of the numbers laid, from day to day, during the first half of the period.

The female, in March and April, which oviposited for eighteen days out of the twenty-one which constituted her adult life, produced 136 larvæ, but 16 must be counted as doubtful. This number, however, does not represent the total number, as the leaves on which the female was kept from the twelfth day to the seventeenth, inclusive, were accidentally detached from the plant and were lost as far as results were concerned. A daily record is not available in this case.

The female, during the latter part of May, which oviposited for fifteen days out of the seventeen which constituted her adult life, produced 25 larvæ, 5 of which are doubtful, and deposited 76 eggs, larvæ and eggs

together totaling from 76 to 81. The eggs deposited after the third day of the oviposition period failed to hatch for some reason. As it was rather difficult to make out the eggs on this particular plant, and made more difficult some days because of poor light, the number of eggs counted in all probability falls short of the actual number laid. The daily record was as follows: —

$$5\text{–}\overset{1}{19}\text{–}\overset{4}{16}\text{–}4\text{–}1\text{–}4\text{–}5\text{–}5\text{–}1\text{–}2\text{–}1\text{–}1\text{–}6\text{–}3\text{–}3=\frac{5}{76}$$

As in the first case, the upper figures represent the doubtful ones.

This female deposited the greatest number of eggs for a single day the second or third day, and she deposited at least half of the total during the first three days of the oviposition period. In this case, as in the first, the great bulk of the eggs was laid during the first half of the period.

In other cases newly emerged virgin females were confined with males in cylinder jars until they coupled. As soon as they separated, they were isolated on plants, one female on a plant, in cages in the insectary. New males were introduced from time to time to insure fertilization. Of the three females thus confined, however, only one was successfully carried through a complete egg-laying period. In this case the pupæ produced were counted, as it was impossible to count either the eggs or larvæ without allowing the female to escape; the number counted was 132.

Length of Adult Life.

In these experiments, as in some of the others, cheesecloth bags were again made use of, males and females together, and females by themselves, being confined within the bags upon leaves on plants in the laboratory. In all cases, except one in which a male lived as long as a female, the females lived longer than the males, the length of life of the males ranging from four to thirty days, while that of the females ranged from eleven to forty-seven days. In a number of cases the segregated females lived much longer than those confined with males, their length of adult life ranging from eleven to sixty-seven days.

Whether the phenomenon of the longer life of some of the females kept by themselves was merely a coincidence, or whether it was due to their not having the opportunity to mate, the writer is unable to say, in absence of more extensive data.

In absence of food, the greatest longevity — the usual (a single individual lived four days) — was three days.

The Egg. (Plates I. and II., Figs. 3, 5.)

The egg is colorless, somewhat cloudy; smooth; elongate oval, though rarely oval, somewhat broader towards one or the other end, more often towards the posterior, and, as a rule, more bluntly rounded at the anterior end; a compound microscope reveals a gelatinous cap at the anterior end,

over the micropyle. It is somewhat variable in size: a number of measurements taken showed a length of .25 to .33 millimeter and a width of .14 to .17 millimeter. Its length is, as a rule, slightly more than twice its width.

The segmented embryo is easily made out under the compound microscope in an egg somewhat advanced in its period of incubation. In a still older egg the embryo is found to be already provided with its dark chitinous rake or rasping organ, the dark color of which contrasts strongly with the general paleness of the rest of the body. Another feature of such an embryo is its restlessness. Shortly before hatching this restlessness or activity is strongly marked.

Length of Egg Stage.

The period of incubation is dependent upon the temperature at which the eggs are incubated. To determine the length of this period eggs were marked at the time of their deposition within leaves of plants in the insectary, and these were then periodically examined for their hatching. In other instances, egg-laying females were confined within cheesecloth bags for short periods, upon leaves on plants kept in the insectary, and on others kept in the laboratory, and the eggs deposited in them were then examined from time to time, as in the above cases, for their hatching. The eggs incubated in the laboratory, where the temperature was higher, hatched in from two and one-half to three days after they were deposited. In the insectary, however, where the temperature approximated more or less to that at which marguerites are kept, — about 55° at night and about 65° to 70° during the day (it fell somewhat below and rose somewhat above this both at night and during the day),— they hatched in from a little over four and one-half to somewhat over five and one-half days. The great majority, however, hatched in from nearly five to somewhat over five and one-half days. The greater variation in the length of the period in the insectary was probably due to the greater variation in the temperature, — a condition which could not very well be avoided. There is a record of a period of six and one-half days in the case of two eggs. The writer, however, cannot vouch for its correctness. The larva begins feeding immediately after hatching.

THE LARVA. (PLATES I. AND II., FIGS. 4, 6.)

The larva or maggot mining within the leaves is colorless, the greenish-yellow cast which marks the posterior half being imparted by the green and black pellets of leaf tissue or food which in chain or strand like formations are visible through the body wall. In form it is súbcylindrical, tapering anteriorly and posteriorly from the region of the fifth and sixth segments, terminating subacutely anteriorly, and truncately posteriorly. When fully developed it measures about 3.5 millimeters in length and .75 millimeter to slightly over in width across its stoutest portion. It is composed of twelve segments. The first segment is very small and appears

like a papilla of the much larger second segment, and contains, ventrally, the mouth opening; segments three and four are comparatively short; the five terminal segments are distinctly longer than the five segments immediately anterior to them. Two contiguous subcylindrical caudal spiracles, dark terminally, project backward from the dorsal portion of the apical end of the last segment. These spiracles are connected by sinews and branched, longitudinal, dorso-lateral, tracheal trunks, one on each side of the body, with the two contiguous cephalic spiracles situated dorsally on the posterior portion of the second segment, each caudal spiracle being connected with the cephalic spiracle on its own side. The anal opening is located at the posterior end of the terminal segment, on the ventral aspect. At the anterior end is seen the dark-colored chitinous and forked oral appendage or rasping organ, conspicuous for its dark color.

The rasping organ or rake is composed of two similar halves lying side by side. They are joined at some points in their course, and the interval between them at other points is so small that it is difficult to make them out at those points as distinct pieces. Each half consists of a short, stout anterior piece or head, the anterior margin of which is modified into strong teeth, and of a more slender and elongate posteriorly forked framework to which the toothed head is attached. The upper of the two posterior prongs is somewhat arched and is longer than the straight lower one. The two halves are joined for a short distance in the vicinity of the heads and at the posterior portions of the lower prongs. The heads are but slightly separated. The whole works as a unit.

In the mine the larva lies on one side, moving along by bodily or muscular contractions aided very likely by its rasping organ, — which can be seen with the aid of a lens, swinging quite rapidly in a dorso-ventral plane, — with which it can grasp and attach itself to the leaf tissue. Taken out of the mine, or uncovered within the mine by rupturing the overlying epidermis, it is practically helpless. It seems unable to pierce the epidermis of the leaf and start a new mine, nor does it know how to continue feeding in the opened mine. Feeding is, as a rule, attempted, but the attempts are feeble. Thus exposed, it remains active for some time, but its helplessness in this new environment is plainly apparent; its various motions bespeak but a helpless despair. The bulk of its energy soon spent, its activities gradually lessen and finally cease, death resulting in a few hours — the time depending upon the conditions to which it is exposed — from a loss of bodily moisture. In water it continues to live for a much longer period — one lived for slightly over twenty-four hours.

As will be recalled, the eggs are as a rule placed from the lower surface, immediately above the epidermis. The larvæ on hatching, however, do not remain feeding on the spongy parenchyma. With a few exceptions they soon make their way to the palisade parenchyma immediately below the epidermis of the upper surface, where they continue for the remainder of their larval existence, going down again, as a rule, only when the supply

of food in their course has been previously exhausted by a brother miner, or to pupate. They make their way to the palisade parenchyma either by mining over the edge of the leaf or by boring directly through the central portion of the mesophyl. Rarely the newly hatched larva will bore its way through in this fashion almost immediately, leaving no trace of its existence whatsoever on the lower surface.

The writer's curiosity was early aroused by this habit of the larva. Of a number of reasons which at first suggested themselves to account for it, only two were finally retained as being the more likely, viz., light and food. The question to be answered, then, was: Is the larva attracted to the palisade parenchyma because of the more and greater degree of light which that surface received, or because of the better food conditions which the palisade parenchyma affords? As regards the latter part of the question, it is well known that the palisade cells composing the palisade parenchyma are compact or close together, while the cells comprising the spongy parenchyma are separated by comparatively large interspaces.

To determine whether light or food was the influencing factor, a number of simple experiments were undertaken. In one series, the upper surface of leaves which were infested by newly hatched larvæ, which larvæ had not as yet made their way to the palisade parenchyma, were darkened by being painted over with India ink.

To guard against inconclusiveness of the first series, owing to the possibility of the ink penetrating and proving repellent, another series of similarly infested leaves were covered with black paper impervious to light. In other cases similarly infested leaves were so fixed as to cause them to remain in an upright position so that both surfaces received an equal amount of light. In still other instances such leaves were so fixed as to reverse their surfaces, the true lower surfaces being turned up towards the better light, the true upper surfaces being turned so as to receive less light. In a few other cases areas directly in the course of larvæ which were already mining in the palisade parenchyma were darkened for the purpose of determining the behavior of the larvæ when the darkened areas were reached.

As a result of the above experiments it may be said that the influencing factor is food supply. Light, however, did appear to be somewhat of an influencing factor in some instances in the case of young larvæ.

The mining (Fig. 10) as it appears on the surface of the leaves shows no particular design. It appears as straight or irregular lines running transversely or diagonally, but usually in a longitudinal direction, and often in loops. This condition is still further complicated in leaves which are infested by more than one larva. In such cases the mining may be seen in patches, or, as it very often happens, the entire leaf is mined. A favorite course for mining is along the margin of the leaf. Within the mine the course of the larva may be traced by a chain of black pellets of excreta which it leaves in its wake.

The mines, or better, perhaps, the channels, are as a rule within the

palisade parenchyma, but they dip down now and then into the spongy parenchyma, and, as it often happens, a large portion of a mine may be wholly in the spongy parenchyma immediately above the epidermis of the lower surface. Often, when the food supply is limited, owing to the size of the leaf, or when there are a number of larvæ within one leaf, the entire mesophyl or fleshy portion of the leaf is devoured.

Length of Larval Life.

The length of the larval period, like that of the egg, varies with the temperature to which it is subjected, and is in all probability modified in addition by the relative abundance of food. Of the number of larvæ kept under observation from the day of their hatching, 122 were successfully followed to the day of their pupation, and are available. Sixty-one, or one-half the total number, were mining in plants which were kept in the insectary and were subjected to a temperature similar to that to which the eggs were subjected. The remaining 61 were subjected to a temperature which was, on the whole, much higher (unfortunately the exact temperature is not available) than that to which the first lot was subjected, the plants which they were infesting being kept in a room adjoining the insectary. Again, those in the insectary were followed during November, and the plants in which they were feeding were inclosed within cheesecloth bags to avoid further infestation. The second lot, on the other hand, were followed during February; and as the plants in which they were feeding were kept in a room which was free of adult flies, they were not covered. In both series the killing of larvæ other than those which were being followed had to be resorted to from time to time in order not to lose track of the others.

TABLE I. — *Length of Larval Life of 61 Larvæ in the Insectary during November, at a Temperature of about 55° at Night and of about 65° to 70° during the Day. (See Temperature in Connection with Length of Egg Stage.)*

Number of Larvæ.	Length of Life (Days).	Number of Larvæ.	Length of Life (Days).
7, ...	11	5, ...	14½
4, ...	11½	4, ...	15
9, ...	12	1, ...	15½
3, ...	12½	3, ...	16
9, ...	13	2, ...	16½
5, ...	13½	1, ...	17
7, ...	14	1, ...	18

It is thus seen that there is quite a variation in the period of growth or development of the larvæ, independently of temperature. Food supply probably accounts for some of this variation.

TABLE II. — *Length of Life of 61 Larvæ in the Room adjoining the Insectary during February, at a Temperature, on the Whole, much Higher than that during November.*

NUMBER OF LARVÆ.	Length of Life (Days).	NUMBER OF LARVÆ.	Length of Life (Days).
11, ...	6	4, ...	9
23, ...	7	1, ...	9½
4, ...	7½	2, ...	10
8, ...	8	2, ...	11
6, ...	8½		

A comparison of the two tables will show at once the difference in the lengths of the larval periods of the larvæ of the two lots, due to difference in temperature. It should be noted also that there was almost as great a range of variation in the development of the individuals of this lot as in that of the first.

PUPARIUM AND PUPA. (PLATES II. AND III., FIGS. 7, 8, 11.)

Pupation takes place within the larval mine and inside the last larval skin, the latter thus becoming a puparium. The larva when full grown merely shortens up and becomes inactive. Before becoming inactive, however, it deepens slightly that portion of the mine in which it is to come to rest, forming a more comfortable bed or resting place for itself, as one might say. Having done this, it turns upon its dorsal surface and gradually assumes a state of inactivity, becoming yellowish-white opaque at the same time.

The puparium, at first of the color of the contracting maggot or larva, — pale yellow, — becomes in time dull pale yellow or straw color, or it turns to reddish brown, brown and dark brown, darkening with age. It is easily perceived by the unaided eye through the pale, semitransparent epidermis on either surface of the leaf (Fig. 11). Normally it is completely covered by the epidermis, only the minute cephalic spiracles at the extreme anterior end projecting. The caudal or anal spiracles are completely covered, and are not visible on the surface. Dr. Lintner must have mistaken the cephalic spiracles for the anal, in stating that the latter are "thrust outward" through the epidermis. (Fourth Report on the Injurious and Other Insects of the State of New York, 1888, pp. 74, 75.)

The apparent displacement of the cephalic spiracles (see larva) is brought

about by the contraction of the anteriormost ventral larval segments before the larva becomes inactive, drawing along with it, first upward then analward, the anterior dorsal portion of the body. As a consequence, the cephalic spiracles, which in the larva are situated on the posterior portion of the second dorsal segment, assume an anterior ventral position in the puparium.

In shape the puparium may be said to be scaphiform or boat-shaped. In outline it is long oval, and approximates in a general way towards that of the larva, being broadest anterior to the center, and tapering from its stoutest portion anteriorly and posteriorly, terminating acutely anteriorly and somewhat truncately posteriorly. As a rule, the length is twice the width (width across the stoutest portion), although not infrequently the width exceeds half the length. A large number of measurements showed a length of 2.25 to 3 millimeters and a width of 1 millimeter to 1.5 millimeters. The greatest width does not necessarily go with the greatest length. The segments are quite strongly marked, and the spiracles are prominent.

While the puparia are seen through the epidermis (Fig. 11) on either surface of the leaf, by far the greater number occur near the lower surface, the proportion being about 2:1; that is to say, pupation takes place more often immediately above the epidermis of the lower surface of the leaf than immediately below the epidermis of the upper surface, the larvæ when about full grown making their way towards the lower surface for that purpose by eating their way through the central portion of the mesophyl. The mining is continued, as a rule, for a greater or lesser distance, after they have eaten their way through.

The puparial content, at first a semiliquid, whitish mass which clings to the wall of the puparium, gradually hardens, through the loss of its fluids, into a white mass distinct from the puparial wall. This mass then gradually differentiates into the pupa proper, which shows the three primary regions — head, thorax and abdomen — of the adult insect, and the rudimentary legs and wings or wing buds. The pupa proper is formed within two and one-half days after pupation at a temperature of about 60° at night and 70° and over during the day, — temperatures slightly higher than those at which marguerites and low-temperature loving plants of its kind are usually kept. It is quite probable that at those lower temperatures the results would be slightly modified. The pupa proper is cream-white in color; the legs are folded on the ventral surface; the wing buds are pressed closely to the sides of the body, their apical portions inclining ventrally.

Length of Pupal Life.

The length of the pupal period, like that of the egg and larva, varies with the temperature, as will be seen by the tables that follow. In all, the periods of 197 are available. One hundred and thirty-four of these developed in plants in the insectary during November, and were subjected to a temperature similar to that to which the eggs and larvæ were sub-

jected. In fact, the greater number of this lot were the pupæ of the larvæ which were followed in the insectary for the purpose of determining the length of the larval period. The remaining 63 developed during the last days of February and the first part of March, and, like their larvæ, in the room adjoining the insectary, where the temperature was markedly higher than in the insectary.

TABLE III. — *Length of the Pupal Period of 134 Pupæ which developed in the Insectary during November, at a Temperature of about 55° at Night and of about 65° to 70° during the Day. (See Temperature in Connection with Length of Egg Stage.)*

Number of Pupæ.	Length of Pupal Period (Days).	Number of Pupæ.	Length of Pupal Period (Days).
2,	12	15,	14½
2,	12½	20,	15
27,	13	2,	15½
18,	13½	1,	16
47,	14		

It is thus seen that the length of the pupal period also varies independently of the temperature. The variation, however, it should be noted, is less than among the larvæ, as might be expected, especially among the larvæ which, like the pupæ, developed in the insectary, and with which they should more properly be compared. It should also be noted that a period of from thirteen to fifteen days, inclusive, embraces the great majority, indeed, almost all.

TABLE IV. — *Length of the Pupal Period of 63 Pupæ in the Room adjoining the Insectary, during February and March, at a Temperature, on the Whole, much Higher than that in the Insectary during November.*

Number of Pupæ.	Length of Pupal Period (Days).	Number of Pupæ.	Length of Pupal Period (Days).
7,	8	26,	10
1,	8½	1,	10½
19,	9	3,	11
3,	9½	3,	12

A comparison of the two tables will show at once the difference in the lengths of the pupal periods of the two lots of pupæ, due to the difference

in temperature. Of interest, also, is the fact that the range of variation in the two lots was the same.

The newly emerged perfect female may be described as follows: head, pale yellow, with a broad central longitudinal black band on the occiput; antennæ, black; thorax, grayish; macrochetæ, black; wings, gray, pale at base, unspread; legs, black, with pale-yellow markings on femora and tibiæ; abdomen, pale yellow, dorsally and ventrally, with darker transverse, broad bands, one on each segment; setæ, black; terminal segment, black.

Length of Life Cycle.

The length of a generation varies, owing to the variability of the stages constituting it. The mean or average length of a life cycle, however, may be obtained by combining the mean or average length of each stage.

The average lengths of the periods constituting the life cycle during November, at a temperature at which marguerites are usually kept (see temperature in connection with length of egg stage), are as follows: —

	Days.
Time elapsing between emergence of adult and oviposition,	$1\frac{1}{2}$
Length of egg stage,	5
Length of larval stage,	13
Length of pupal stage,	14
Average length of one generation,	$33\frac{1}{2}$

Number of Generations in the House.

Knowing the length of a generation, we can calculate the approximate number of overlapping generations or broods which occur in the house from the setting in of the cooler season, when the flies make their first appearance in the house, or when they reappear, or appear in greater numbers, to about Easter, when most of the marguerites are sold out, or to the end of May, in cases where the plants are grown for their bloom. Thus there are at least four complete broods for the period between November 1 and April 1, and at least six complete broods for the period between November 1 and June 1, for a life cycle of thirty-three and one-half days. Owing to the higher temperature during April and May there may be an additional generation, or partial generation, for the period between November 1 and June 1.

Hibernation.

Is the insect able in some one of its stages, say pupa, to pass the winter out of doors? This question is suggested by a letter from Mr. Walker Holden. According to this letter the marguerites and feverfews in Mr. Holden's greenhouse were badly infested by the insect during the winter of 1911. The following spring these plants, as was the practice, were removed from the house to the garden for the summer, and towards fall furnished the cuttings for a new crop. That fall and winter (1911–12), however, there were no signs of the insect in the greenhouse. In the spring

the house was again cleared, and the plants, apparently perfectly clean, removed to the garden. In late summer, however, Mr. Holden found the plants infested, and during the following fall and winter (1912–13) the insect was again present in troublesome numbers in his greenhouse.

How is the absence of the fly during the fall of 1911 and winter of 1912 to be accounted for? As there are no other greenhouses in Mr. Holden's vicinity, it could not have passed the winter actively in a neighboring greenhouse. Unless, then, as is possible, it passed the winter in some near-by dwelling house, where some one of its food plants was kept for ornamental purposes, as occasionally happens, hibernation is the only rational explanation that remains.

CONTROL.

Picking of Leaves.

Until recently the picking and destruction of the infested leaves was the only means known for the control of this insect. This method, however, aside from other disadvantages, has not proven effective in all cases. Mr. Walker Holden has had fairly good success with it in the case of white marguerites, but it was utterly ineffective in the case of yellow marguerites, and it rendered the feverfews unsalable. It is quite probable, also, that he would have experienced more difficulty in connection with the white marguerites had he not had in the house at the same time yellow marguerites and feverfews, of which plants the flies are very fond. But aside from the consideration of effectiveness, it is obvious that as a means of control the method is by itself unsatisfactory in cases where plants are grown in quantity and time is valuable. Moreover, the loss of leaves is not to the advantage of the plant.

Spraying.

"Black Leaf 40."

It was the intention of the writer to discover, in connection with his other studies of the pest, a more effective method of control. But before the experiments along these lines were begun, a note entitled "A Remedy for Chrysanthemum Leaf Miner," in the "Journal of Economic Entomology" for December, 1912, by J. G. Sanders of the College of Agriculture, Madison, Wis., came to his notice. In this note Mr. Sanders says in part, as follows: —

> While experimenting with contact insectides for their control, the nicotine solutions, especially "Black Leaf 40," used as a spray with or without whale-oil soap solution, proved a complete and satisfactory control. One part of nicotine in 400 parts of water killed the eggs and larvæ readily, as well as the newly formed pupæ. The pupæ of all ages were killed with $\frac{1}{200}$ nicotine solution.

Mr. Sanders having discovered an effective remedy, the writer thought it superfluous to experiment further along original lines; nor, again, did the time available make it convenient for him to do so. His own experi-

ments, therefore, were designed merely to test Mr. Sanders's results. A solution of 1 part of "Black Leaf 40" in 400 parts of water killed the eggs and the larvæ readily, as Mr. Sanders has pointed out, and a large proportion of the newly formed pupæ. A solution of 1 part of "Black Leaf 40" in 200 parts of water killed a large proportion of the older pupæ. The addition of whale-oil soap did not seem to give any better results.

The "Black Leaf 40," which is a concentrated solution of nicotine sulfate, containing 40 per cent. active nicotine, is manufactured by the Kentucky Tobacco Product Company, Louisville, Ky. It is sold in ½, 2½ and 10½ pound cans, and may be obtained direct from the manufacturers, if it cannot be obtained from a near-by dealer.

"Nico-Fume" Liquid.

Mr. W. R. Nicholson of Framingham was referred to the writer, by Prof. E. A. White of the Department of Floriculture, as one who in all probability was in a position to furnish information regarding the pest. The writer took the opportunity soon after to consult Mr. Nicholson. According to Mr. Nicholson, who grows marguerites on a large scale, the insect was very troublesome in his houses a few years ago. While experimenting with various methods and materials in an effort to control it he tried "Nico-Fume" Liquid as a spray, and found it effective. He has experienced little or no trouble from the insect since he has been systematically using this liquid.

Mr. Nicholson dilutes the "Nico-Fume" in water from about 430 to 450 times, using a cupful — a cup which the manufacturers provide — to 3 gallons of water, and sprays regularly once a week. He begins spraying even before there are any indications of the presence of the insect, preferring to get the start on them rather than have the insect get the start on him. He sprays not only against the Marguerite Leaf Miner with the material at this strength but also, his other plants as well, against aphids. In fact, he is using it as general spray more against aphids and other soft-bodied insects than against the Marguerite Miner, which is of little or no consequence in his houses now. Mr. Nicholson has found no occasion to add soap to the solution.

"Nico-Fume" Liquid, like "Black Leaf 40," is a nicotine solution containing 40 per cent. active nicotine, and is prepared by the same manufacturers. It may also be obtained in the same way. It is sold in ¼ pint, pint, ½ gallon, and gallon cans.

"Nicoticide."

Mr. Nicholson has also used "Nicoticide" at the same strength and in the same way as the "Nico-Fume" Liquid, with equally good results.

"Nicoticide," like the "Black Leaf 40" and the "Nico-Fume" Liquid, is a nicotine solution. It is manufactured by the P. F. Palethrope Company, Owensboro, Ky. It may be had in ounce, ½ pint, pint, and gallon cans.

Relative Cost of the Spraying Materials.

An absolute comparison of the prices of the three spraying materials is not possible for the reason that they are not all sold in similar quantities. A fairly good idea of the relative cost of the "Nico-Fume" Liquid and the "Black Leaf 40," however, may be had from the figures which follow, which indicate the cost per ounce of these materials in each of the quantities in which they are on the market.

"Black Leaf 40."

One ounce in ½ pound costs 10.62 cents.
One ounce in 2½ pounds costs 8.12 cents.
One ounce in 10½ pounds costs 7.44 cents.

"Nico-Fume" Liquid.

One ounce in ½ pint costs 11.76 cents.
One ounce in 1 pint costs 8.82 cents.
One ounce in ½ gallon costs 8.08 cents.
One ounce in 1 gallon costs 7.72 cents.

It is thus seen that, on the whole, the "Black Leaf 40" is slightly cheaper per ounce than the "Nico-Fume" Liquid. The "Nico-Fume" Liquid, however, possesses a possible advantage in that it may possibly be used at a slightly lower strength, Mr. Nicholson using it at the rate of 1 part to about from 430 to 450 parts of water, while from his own experiments with "Black Leaf 40" the writer prefers a $\frac{1}{400}$ solution of the latter to that of a $\frac{1}{450}$ solution. It is quite probable, however, that where spraying will be practiced regularly, as is Mr. Nicholson's practice, the "Black Leaf 40," used at the same strength as the "Nico-Fume" Liquid, may prove just as efficient as the "Nico-Fume."

The tables also show very clearly the advantage of buying either material in the larger quantities.

"Nicoticide" as a spray is entirely too expensive as compared with "Black Leaf 40" and "Nico-Fume" Liquid. It costs $1 more per pint, $3 more per ½ gallon, and $4.50 more per gallon than the "Nico-Fume" Liquid, and one pays 17.5 cents per ounce when buying it in ¼ of a pound quantities.

Conclusions and Recommendations.

It is the opinion of the writer that in a general way the method of combating the Marguerite Miner followed by Mr. Nicholson (see "Nico-Fume" Liquid) might be used by others, certainly by large growers of marguerites and those other plants which the insect attacks. The method has proved itself both effective and economical in the hands of a practical and successful florist, and it has stood the test for several years. However, if one has never been troubled by this insect, and if his practice is to fumigate rather than spray against aphids, spraying should begin with the first signs of the operations of the insect. The second application may

well follow one week later, as it is highly desirable that the insect be checked to as great a degree as possible at its very start. The spraying should then be continued regularly every eleven or twelve days. A longer interval than twelve days is not advisable, as it is more difficult to kill nearly full-grown or full-grown larvæ, and pupæ are still more difficult. In spring, when it becomes warmer in the house, — or at any time if the plants are grown at a higher temperature than usual, — the sprayings will probably have to come a little more often. Should one succeed in exterminating the insect, spraying might be discontinued after cold weather has set in, for then the danger of the insect's coming into the house is past. With the coming of spring, however, one's vigilance should be renewed, for if the insect is able to pass the winter outside of the greenhouse in a dormant state, that is, to hibernate, there is a possibility, it may get into the house when it becomes active again. If "Black Leaf 40" instead of "Nico-Fume" Liquid is used, it should, at first at least, be used at the $\frac{1}{400}$ strength. Later, especially if one should spray regularly, 1 part to about from 430 to 450 parts of water, at which strength Mr. Nicholson uses the "Nico-Fume" Liquid, might very likely prove effective.

The importance of thorough spraying cannot be overemphasized, as the insect multiplies very rapidly under normal conditions. Both surfaces of the leaf should be entirely and uniformly covered, as the eggs, larvæ and pupæ may occur in any part of the leaf. Special pains should be taken to hit the lower surfaces of the leaves, as from the lower surfaces will be reached the majority of the eggs and newly hatched larvæ — which will thus be cut off at the very beginning of their career of mischief — and full-grown larvæ and therefore pupæ. As the solution must penetrate into the tissues to do its work, it is important also that it adhere well to the leaves. A nozzle giving a fine spray should therefore be used. Should difficulty for some reason or other be experienced in this respect, the addition of soap might be advisable, — whale-oil soap or good laundry soap, at the rate of 1 pound to about 30 gallons of water. The soap increases the adhesiveness of the spray solution through its own adhesive character, and by lessening the formation of drops the last property insures a more even and uniform distribution of the solution on the leaf surface as well.

The soap should be dissolved in water before the "Black Leaf 40" or "Nico-Fume" Liquid is added — the soap cut in thin slices will easily dissolve in some boiling water. After adding, the solution should be stirred thoroughly to obtain uniformity. More material than is needed for one application should not be prepared; in other words, the materials should be mixed shortly before applying.

Natural Enemies.

Spiders.

The various spiders occurring in the greenhouse, by preying upon the adult flies, capturing them directly, and indirectly by enmeshing them in their webs, are of aid to the florist in that they reduce the numbers of

the flies. Especially serviceable seems to be *Salticus senicus* Clerk (identified by Mr. J. H. Emerton of Boston), a gray, brownish, and white form, about one-fourth of an inch long, common in and outside of houses all over North America. The front of its head around and above the eyes is white; there is a white band across the anterior end of the abdomen, and two or three oblique white bands on the sides. In some cases a longitudinal white band passes down the middle of the abdomen. This spider is a plant crawler, and the writer has observed individuals again and again on the marguerite plants, preying upon the adult flies.

According to Mr. Whiting of the Department of Floriculture this spider is very valuable in greenhouses in general, preying extensively on the various aphids, on the Rose Leaf-roller (*Archips rosaceana* Harris), extracting the larva from out of the rolled leaf, and on other injurious forms.

Insect Parasites.

As far as the writer knows, no definite insect parasite of the Marguerite Fly has as yet been reported. The late Mr. D. W. Coquillett, however, was of the opinion that such a parasite exists. Referring (Insect Life, VII., 1894–95, p. 400) to some marguerite leaves which he received from the greenhouses of Mr. James Read of Irvington, N. Y., Feb. 28, 1890, from which adults of the Marguerite Miner were reared, he adds: —

> Quite a large series of chalcidid flies belonging to the genus *Chrysocharis* were also bred, but as the other members of this genus are almost without exception parasitic upon other chalcidid or Ichneumon flies, it is quite certain that the present specimens did not prey upon the leaf miners. Their presence, however, is indicative of the very important fact that these miners have an enemy to contend with in the form of a small four-winged fly that has thus far escaped detection.

SUMMARY OF RESULTS.

History and Distribution.

The Marguerite Fly, or Chrysanthemum Leaf Miner is, as far as known, a native insect. It was first reported from a greenhouse near Glen Cove, N. Y., in the fall of 1886. It has since been found in many other localities. At the present time it is definitely known to occur in the following States: New Hampshire, Massachusetts, Connecticut, New York, Pennsylvania, Illinois, Wisconsin and Montana. It is doubtless present in other States.

Host Plants.

The food plants of this insect are apparently restricted to the family Compositæ. Of the cultivated plants, marguerites and feverfews seem to be the favorites. It is also known to attack eupatoriums, gazanias, helianthus, cinerarias, tansies, chrysanthemums, goldenrod, ragweed, dandelions, beggar-ticks, wild carrot, the common white or ox-eye daisy, and everlasting, or ladies' tobacco. It is essentially a greenhouse pest.

Injury and Seriousness of the Pest.

The injury is caused by the larvæ or maggots mining within the leaves, and living upon the mesophyl or fleshy portion of the same. The mining is seen on the surfaces of the leaves as irregular, whitish lines or patches, the latter often extending to take in the whole surface, and causes the death of part or the whole leaf. The activity of the larva or maggot results in a serious interference with normal growth, in checking flowering or in the reduction of the number of flowers normally produced, and in a reduction in the size of the flowers. Small plants may be killed in a comparatively short time if exposed continually to attack. The depredations of the insect are often very serious. In many instances the commercial growing of marguerites and other Compositæ have been given up on account of it.

Life History and Habits.

The adult insect is a small, grayish fly, only 2 millimeters, or $\frac{1}{12}$ of an inch, long, with a comparatively broad yellow stripe or band on each side of the abdomen, and may be seen resting, or crawling lazily about, or making its way from plant to plant in a skipping or hopping flight. The female fly, as a rule, lives longer than the male. Females confined with males upon leaves on plants in the laboratory lived as long as a month and a half. One female may lay between 125 and somewhat over 150 eggs during her lifetime. The eggs are laid singly in horizontal incisions made by the ovipositor, between the parenchyma, or flesh, and epidermis, or skin, of the leaf, — principally between the parenchyma and epidermis of the lower surface. Similar incisions are made, but mostly between the parenchyma and epidermis of the upper surface, for purposes of feeding on the juices of the leaf. The eggs hatch in from slightly over four and a half to somewhat over five and a half days. The larvæ do most of their feeding immediately beneath the epidermis of the upper surface of the leaf, owing to the better food conditions afforded by the palisade parenchyma, and may feed as long as seventeen and eighteen days. Pupation takes place within the larval mine, and more often in those immediately above the epidermis of the lower surface of the leaf. The pupa stage lasts, as a rule, from thirteen to fifteen days, inclusive. The mean or average length of a complete life cycle or generation is about thirty-three and one-half days. The lengths of the different stages vary also with the temperature to which they are subjected. The above periods are for a temperature at which marguerites are usually grown. (See temperature in connection with length of egg stage.)

Control.

The insect may be controlled by spraying with the nicotine solutions "Black Leaf 40," "Nico-Fume" Liquid and "Nicoticide," diluted from 400 to 450 times in water, and applied at intervals of eleven or twelve

days, or somewhat oftener if the temperature in the greenhouse is higher than that at which marguerites are usually kept. The picking of leaves, it would seem, is in most cases neither adequate nor satisfactory.

Bibliography.

1905, Aldrich, J. M., A Catalogue of North American Diptera.

1911, Britton, W. E., Chrysanthemum Leaf-Miner or Marguerite Fly. Eleventh Ann. Rept. St. Ent. Conn., p. 342.

1912, Cooley, R. A., Marguerite Fly (*Phytomyza lateralis* Fall). Tenth Ann. Rept. St. Ent. Mont., Bull. 92, Mont. Agl. Exp. Sta., p. 56.

1894–95, Coquillet, D. W., A Destructive Leaf-Miner on the Chrysanthemum. Ins. Life, Vol. VII., pp. 399–401, illus.

1898, Coquillet, D. W., *Phytomyza chrysanthemi* Kowarz. Bull. 10, n. s., Div. Ent., U. S. Dept. Agr., p. 79.

1887, Falconer, Wm., The Marguerite Fly (*Phytomyza affinis*). The American Florist, Vol. II., p. 297.

1890, Jack, F. G., Diseases of Chrysanthemums caused by Insects. Garden and Forest, Vol. III., pp. 439, 440, illus.

1888, Lintner, J. A., *Phytomyza lateralis* (The Marguerite Fly). Fourth Ann. Rept. St. Ent., N. Y., pp. 73–79, 207, illus.

1891, Lintner, J. A., *Phytomyza chrysanthemi* Kowarz (The Chrysanthemum Fly). Seventh Ann. Rept. St. Ent. N. Y., pp. 242–246, illus.

1893, Lintner, J. A., The Marguerite Fly. Ninth Ann. Rept. St. Ent. N. Y., p. 421.

1895, Lintner, J. A., The Chrysanthemum Fly (*Phytomyza chrysanthemi* Kowarz). Tenth Ann. Rept. St. Ent. N. Y., p. 510.

1912, Sanders, J. G., A Remedy for Chrysanthemum Leaf Miner. Journ. Econ. Ent., Vol. 5, No. 6, December, p. 472.

EXPLANATION OF PLATES

PLATE I.

FIG. 1. — Dorsal view of adult female fly. Greatly enlarged.

FIG. 2. — Wing of adult fly. Greatly enlarged. 1–6, veins; cos, costal vein; ant. c. v., anterior cross vein.

FIG. 3. — Egg showing contents and gelatinous cap at anterior end. Greatly enlarged.

FIG. 4. — Side view of the anterior and posterior portions of the larva or maggot. Greatly enlarged. fd. or., feeding organ or rake; sp., spiracle; tr., tracheal trunk.

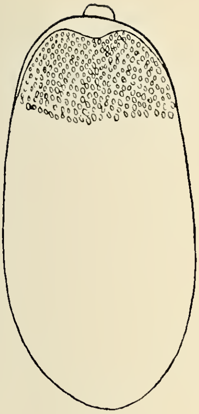

Fig. 3

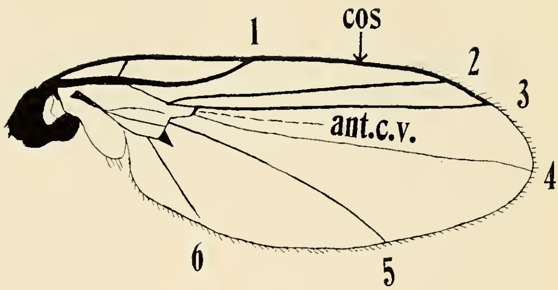

Fig. 2

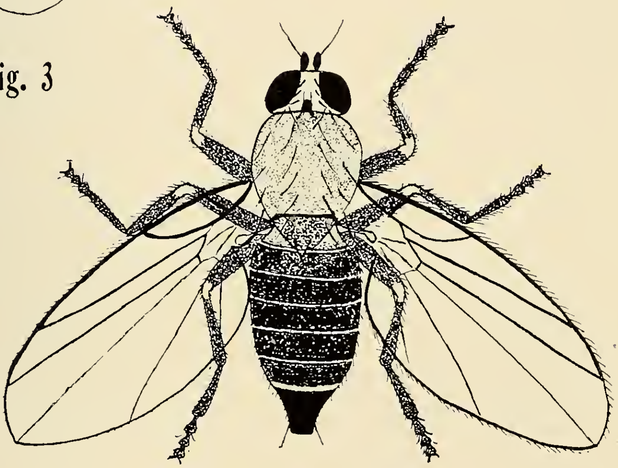

Fig. 1

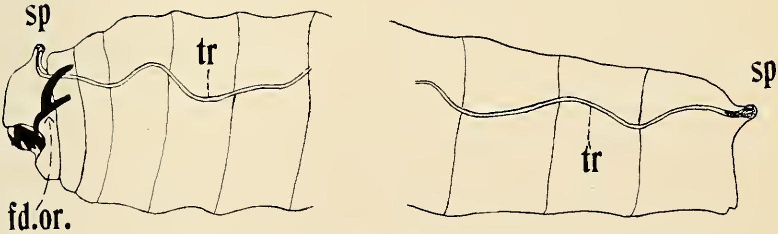

Fig. 4

PLATE II.

FIG. 5. — Egg. Enlarged about twenty-five times.

FIG. 6. — Side view of larva or maggot. Enlarged about nine times.

FIG. 7. — Puparia. Enlarged about twelve and one-half times.

FIG. 8. — Ventral, and latero-ventral view of pupæ. Enlarged about twelve and one-half times.

FIG. 9. — Leaf showing blotches and papillæ produced by the female fly. Enlarged about one and one-half times.

FIG. 10. — Leaf showing the work of the larva or maggot. Natural size.

Fig. 5

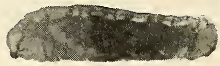

Fig. 6

Fig. 7

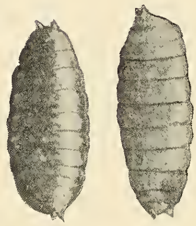

Fig. 8

Fig. 9

Fig. 10

PLATE III.

Fig. 11. — Leaf with pupæ beneath epidermis. Enlarged about three times.

Fig. 12. — A white marguerite plant badly attacked; the dried-up leaves clinging to the plant.

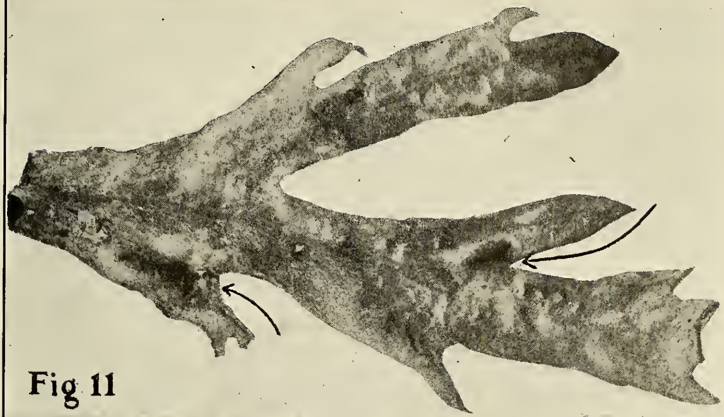

Fig 11

Fig.12

THE COMPOSITION, DIGESTIBILITY AND FEEDING VALUE OF MOLASSINE MEAL, COTTONSEED MEAL AND HULLS, COCOA SHELLS, GRAIN SCREENINGS, FLAX SHIVES, MELLEN'S FOOD REFUSE, AND POSTUM CEREAL RESIDUE (CXX FEED).

J. B. Lindsey and P. H. Smith.

1. MOLASSINE MEAL.

The Molassine meal offered in Massachusetts is an English product[1] composed of substantially 70 to 75 per cent. of cane or beet molasses and 25 to 30 per cent. of sphagnum moss; the latter, as time passes, decays and forms peat. The moss used in Molassine meal, according to the manufacturers, comes from the upper layers of large peat bogs in Yorkshire, Eng., and is probably more or less humified. It is doubtful if the moss has any particular nutritive properties; hence, the *nutritive value* of the feed consists in the amount of molasses present.[2]

Molassine meal is quite dark in color, rather bulky, somewhat moist and slightly sticky, but is in good merchantable condition and appears to keep well.

(1) *Composition of Molassine Meal.*

Analyses made at the experiment station show it to have the following approximate composition: —

	Per Cent.
Water,	18.43
Ash,	7.52
Crude protein,	9.32
Crude fiber,	6.75
Nitrogen-free extract,	57.51
Fat,	.47
	100.00

[1] A product similar to Molassine meal was first made in Germany, where it was patented under the number 79932; it is there known as *Torf-Melasse*. It is also made in France, and known as *Tourbe-Melassée*. Its use in these countries is quite general, particularly as a partial feed for horses.

[2] Kellner and Pfeiffer have shown that peat is without nutritive value.

The presence of so much ash is due to the relatively large amount of molasses. The crude protein is largely in the amino form, and is of doubtful value for flesh and milk production; the extract matter is composed largely of sugar and allied substances; the crude fat or ether extract is of no particular account. A test for potash showed the presence of 4.50 per cent., about the same amount as found in cane molasses.

(2) *Digestibility of Molassine Meal.*

Five trials were made with three different sheep, using 600 grams of hay and 200 grams of Molassine meal in two cases, and 550 grams of hay and 200 grams of the meal in one case. This combination was found to give a rather wide nutritive ratio, so two more trials were made, feeding 550 grams of hay, 150 grams of gluten feed and 200 grams of Molassine meal. The results secured with each sheep, and the average, follow: —

Digestion Coefficients for Molassine Meal.

Sheep.	Dry Matter.	Ash.	Protein.	Fiber.	Nitrogen-free Extract.	Fat.	Nutritive[1] Ratio.
I.,[2]	59.47	65.31	27.19	14.61	71.30	11.34	1:11.50
V.,[3]	58.54	78.47	58.10	-	70.84	72.13	1: 6.17
V.,[2]	66.60	86.95	32.51	25.00	75.32	-	1:10.03
VI.,[3]	64.44	87.85	66.33	-	70.91	63.11	1: 6.13
VI.,[2]	60.86	78.83	24.55	-	71.12	-	1:10.15
Average,	61.98	79.48	41.74	-	71.90	-	-
Cane molasses for comparison.	78.30	54.85	33.34	-	88.84	-	-

[1] Total ration. [2] Fed with English hay. [3] Fed with English hay and gluten feed.

The results show that the Molassine meal has about the same degree of total digestibility as wheat bran. The ash has a high, and the extract matter a fair degree of digestibility. The fiber was poorly utilized; in some instances none was digested. Where Molassine meal and hay were fed the digestibility of the crude protein was low, due in part to the relatively small amount of nitrogen in the ration in proportion to the metabolic by-products. Where gluten feed was added to the ration the digestibility of the protein was considerably higher. The Molassine meal is some 20 per cent. less digestible than cane molasses (proportion of 62 to 78), due to the presence of the sphagnum moss. Applying the digestion coefficients to the analysis of Molassine, one secures the following number of pounds of digestible organic matter in 100 pounds, and by multiplying by 20, the amount in 1 ton: —

Composition and Digestibility of Molassine Meal.

	Composition (Pounds in 100).	Percentage digestible.	Pounds digestible in 100.	Pounds digestible in 1 Ton.
Protein,	9.32	41.7	3.89	77.80
Fiber,	6.75	–[1]	–[1]	–[1]
Extract matter,	57.51	71.9	41.35	827.00
Fat,	.47	–[1]	–[1]	–[1]
Total,	–	–	45.24	904.80

[1] Not determined on account of the unsatisfactory coefficients obtained. Its omission, however, makes little difference in the totals.

The Molassine meal, with 18.43 per cent. of water, is shown to contain 905 pounds of digestible organic matter in 1 ton, as against 1,377 pounds in a ton of corn meal with this same amount of water, and against 1,524 pounds in kiln dried corn meal with 11 per cent. of water. In the former case the Molassine meal would have 66 per cent. of the nutritive value of corn meal, or in the latter case 59 per cent. Viewed solely from the standpoint of nutrition it can safely be said that the material is noticeably inferior to corn or to the other cereals.

(3) *Feeding Experiment with Dairy Cows, 1913.*

This experiment was undertaken for the purpose of comparing the relative value and feeding effect of Molassine meal as compared with corn meal; *i.e.*, to note if the animals would eat the Molassine meal readily, and also to observe its effect upon the general condition of the animal and upon the amount of milk produced.

Six cows were fed by the reversal method in periods of three weeks' duration. Hay, wheat bran and cottonseed meal constituted the basal ration, to which were added definite amounts of either Molassine or corn meal.

Table I. — *History of the Cows.*

Name.	Breed.	Age (Years).	Last Calf dropped.	Served.	Milk Yield (Pounds), Beginning of Trial.
Amy,	Pure Jersey,	5	Dec. 21, 1912	Mar. 4, 1913	24
Betty,	Grade Jersey,	8	Oct. 30, 1912	Feb. 11, 1913	21
Samantha II.,	Grade Holstein,	4	Feb. 13, 1913	– –	35
Fancy II.,	Grade Jersey,	5	Sept. 14, 1912	Jan. 28, 1913	21
Cecile,	Pure Jersey,	7	Dec. 18, 1912	Mar. 9, 1913	21
White,	Grade Holstein,	4	Mar. 12, 1913	– –	43

TABLE II. — *Duration of Experiment, 1913.*

DATES.	Corn Meal Ration.	Molassine Meal Ration.
May 2–May 23,	Fancy II., Cecile, White,	Amy, Betty, Samantha II.
June 6–June 27,	Amy, Betty, Samantha II.,	Fancy II., Cecile,[1] White.

[1] June 13 to July 4 for Cecile.

Twenty-two days elapsed between the two parts of the experiment in case of Cecile, as she could not be induced to eat the full ration of Molassine (4 pounds), and it was finally found necessary to reduce the amount to 3 pounds and add 1 pound of corn meal. The intermediate period for the other cows was fourteen days.

Care and Feeding of Animals. — They were kept in roomy stalls, carded daily and turned into a protected barnyard during each pleasant day. They were fed twice daily; the hay was given some time before milking in the afternoon, and the grain just before milking, while in the morning the grain was given just before and the hay just after milking. Water was supplied constantly by aid of a self-watering device.

Character and Cost of Feeds. — The hay was an admixture of timothy, red top and some clover. Unfortunately, it varied in texture, and during part of the experiment it was rather coarse, which caused the animals to leave small amounts on different days. The bran was of the spring variety. The cottonseed meal was of fair quality, containing about 39 per cent. of protein. The corn meal was local-ground and of good quality. The Molassine meal has already been described. The market price of the several feeds at the time of the experiment was as follows: —

	Per Ton.
Hay,	$23 00
Corn meal,	26 00
Cottonseed meal,	34 00
Wheat bran,	27 00
Molassine meal,	40 00

Weighing the Animals. — Each cow was weighed for three consecutive days at the beginning and end of each half of the trial, before the afternoon feeding.

Sampling Feeds and Milk. — The hay was sampled at the beginning, middle and end of each half of the trial in the usual way, as described in other experiments of this character. The grains were sampled daily, and the samples preserved in glass-stoppered bottles and brought to the laboratory at the end of each half of the trial for dry-matter determinations and complete analyses.

The milk of each cow was sampled daily for five consecutive days for each week of the trial. The usual method of sampling was followed.

TABLE III. — *Analysis of Feedstuffs.*

Character of Ration.	Water.	Protein.	Fat.	Nitrogen-free Extract.	Fiber.	Ash.
Hay,	10.54	9.29	2.22	42.94	28.86	6.15
Bran,	12.13	16.36	4.80	51.46	9.19	6.06
Cottonseed meal,	7.84	39.10	8.51	27.68	10.60	6.27
Corn meal,	14.06	8.87	3.67	70.17	1.98	1.25
Molassine meal,	19.61	9.08	0.41	57.71	6.06	7.13

TABLE IV. — *Total Rations consumed by Each Cow (Pounds).*

Corn Meal Ration.

Name.	Hay.	Bran.	Cottonseed Meal.	Corn Meal.	Molassine Meal.
Fancy II.,	314	42	21	84	–
Cecile,	328	42	21	84	–
White,	464	63	53	105	–
Amy,	369	42	21	84	–
Betty,	371	42	21	84	–
Samantha II.,	483	63	42	105	–
Totals for herd,	2,329	294	179	546	–
Molassine Meal Ration.					
Fancy II.,	330	42	21	–	84
Cecile,	360	42	21	20	63
White,	478	62	51	–	103
Amy,	344	42	21	–	84
Betty,	358	42	21	–	84
Samantha II.,	471	63	42	–	105
Totals for herd,	2,341	293	177	20	523

TABLE V. — *Average Daily Ration consumed per Cow (Pounds).*

Character of Ration.	Hay.	Bran.	Cottonseed Meal.	Corn Meal.	Molassine Meal.
Corn meal,	18.5	2.3	1.4	4.3	–
Molassine meal,	18.6	2.3	1.4	–	4.3[1]

[1] Including 20 pounds of corn meal fed Cecile.

The average daily amount of rations fed was practically the same for both periods. This does not, however, take into account the actual dry matter fed. The small amount of corn meal that it was found necessary to feed Cecile in order to induce her to eat the Molassine is figured as Molassine meal.

TABLE VI. — *Digestible Organic Nutrients in Average Daily Rations (Pounds).*

Character of Ration.	Crude Protein.	Fiber.	Nitrogen-free Extract.	Fat.	Total.[1]	Nutritive Ratio.
Corn meal,	1.98	3.33	8.77	.54	15.27	1:6 7
Molassine meal,[2]	1.89	3.35	7.80	.39	13.90	1:6.4

[1] Including fat x 2.2. [2] With corn meal fed Cecile figured as Molassine meal.

The total average daily nutrients were somewhat less for the Molassine ration than for the corn meal ration, due largely to the fact that the Molassine meal contained rather more water and less digestible matter than the corn meal.

TABLE VII. — *Herd Gain or Loss in Live Weight (Pounds).*

Character of Ration.	Gain.
Corn meal,	15
Molassine meal,	5

The gain in weight for both periods is insignificant, and simply demonstrates that the animals were receiving sufficient food to maintain body and milk requirements.

TABLE VIII. — *Total Yield of Milk Products (Pounds).*

Corn Meal Ration.

Cows.	Total Milk (Pounds).	Daily Milk (Average).	Total Solids (Pounds).	Total Fat (Pounds).	Butter Equivalent (Fat + ⅙).	Average Per Cent. Total Solids.	Average Per Cent. Fat.
Fancy II.,	405.4	19.3	55.42	19.42	22.66	13.67	4.79
Cecile,	384.0	18.3	53.07	18.20	21 23	14.82	4.74
White,	771.8	36.8	96.24	34.04	39.71	12.47	4.41
Amy,	456.7	21.7	62.57	21.88	25.53	13.70	4.79
Betty,	377.7	18.0	53.10	18.17	21.20	14.06	4.81
Samantha II.,	715.9	34.1	89.99	26.92	31.41	12.57	3.67
Total,	3,111.5	24.7[1]	410.39	138.63	161.74	13.19[1]	4.46[1]

[1] Average.

TABLE VIII. — *Total Yield of Milk Products (Pounds)* — Continued.

Molassine Meal Ration.

Cows.	Total Milk (Pounds).	Daily Milk (Average).	Total Solids (Pounds).	Total Fat (Pounds).	Butter Equivalent (Fat + ⅙).	Average Per Cent. Total Solids.	Average Per Cent. Fat.
Fancy II.,	370.6	17.6	49.29	16.71	19.49	13.30	4.51
Cecile,	300.7	14.3	41.26	14.04	16.38	13.72	4.67
White,	631.3	30.1	75.57	25.38	29.31	11.97	4.02
Amy,	429.1	20.4	58.31	21.15	24.68	13.59	4.93
Betty,	368.3	17.5	51.19	17.75	20.71	13.90	4.82
Samantha II.,	621.3	29.6	77.35	24.54	28.63	12.45	3.95
Total,	2,721.3	21.6[1]	352.97	119.57	139.50	12.97[1]	4.38[1]

[1] Average.

It will be seen from the foregoing table that the cows produced substantially 14 per cent. more milk and 16 per cent. more solids and fat on the corn meal ration than they did on the Molassine ration. The milk produced during the corn meal period contained a slightly higher percentage of total solids and fat than did that produced in the Molassine period. This, however, may have been within the limit of error.

TABLE IX. — *Food Cost of 1 Quart of Milk and 1 Pound of Butter for Each Ration.*

CHARACTER OF RATION.	Total Cost of Ration.	Cost of 1 Quart of Milk.	Cost of 1 Pound of Butter.
Corn meal,	$42 61	$0.031	$0 26
Molassine meal,	46 19	.038	33

Adverse Influences. — 1. The fact that the cow Cecile could not be induced to eat the Molassine, and that it was necessary to substitute 1 pound of corn meal for 1 pound of Molassine. As figured, however, this should benefit the Molassine ration.

2. The hay fed did not run as uniform in quality as could have been desired. As all the cows received the same hay each day this should not affect the results obtained.

3. The total corn meal ration contained 18 pounds more dry matter than did the Molassine ration. When this is applied to the average daily ration the difference is very slight.

General Conclusions. — 1. Molassine meal is essentially a carbohydrate feed, but differs from corn meal in containing more water, fiber and ash,

and less fat and carbohydrates. While the protein content is about the same, the protein of the Molassine contains approximately 70 per cent. of amido compounds which are not as valuable as true protein.

2. Molassine meal was found to contain about 470 pounds less digestible matter to the ton than corn meal.

3. In a feeding experiment with 6 cows the Molassine meal ration produced about 14 per cent. less milk and 16 per cent. less solids and fat than did the corn meal ration.

While molasses mixed with moss or peat (of which Molassine meal is a type) renders the former easily handled, and while such a mixture may be used to advantage in some cases, it is believed that at prevailing prices it is likely to prove a decidedly expensive feedstuff, especially for dairy animals.

(4) *Molassine Meal for Horses.*

Mention has already been made of the fact that mixtures of moss or peat and molasses are in common use in Germany, France and England. There is no feedstuff the value of which has been so thoroughly discussed and disputed as has this feed mixture.

The late O. Kellner [1] considered it expensive, recognizing that its nutritive value was to be found only in the 75 per cent. of molasses which it contained. He advised the use of plain molasses, or molasses mixed with bran or other feedstuff.

Lavalard,[2] one of the French authorities on the nutrition of the horse, conducted long-continued experiments, using one-fourth *Tourbe-Melassée* and three-fourths oats, corn and beans, together with some 7 to 8 pounds daily of chopped straw. He states that this combination has given the best results, the animals completely consuming the ration, which was never the case with the ordinary ration fed. He further states that as a result of feeding this ration, large numbers of cavalry horses were well nourished and equal to the work required of them, and with a noticeable decrease in the intestinal troubles which usually occur. The introduction of molasses in the ration led him to fear the injurious effects of the potash salts. His long experience, however, enables him to say that these salts acted both as a tonic and stimulant.

The writer has fed Molassine meal to farm horses and found it to be readily eaten and in no way injurious. The horses to which it was fed were in normal condition beforehand.

In spite of its worthlessness as a food, the moss serves as a satisfactory carrier of the molasses. Emphasis has already been placed upon the high cost of the Molassine meal in proportion to its nutritive value.

(5) *General Statement concerning Molasses as a Foodstuff.*

Molasses has been in use for a considerable time both in Europe and America, either fed by itself or as a component of mixed feeds for all kinds of live stock.

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[1] Die Ernährung d. Landw. Nützthiere, Sechste Auflage, p. 378.

[2] L'alimentation du Cheval, p. 62.

As a result of numerous experiments it has been shown to have substantially three-fourths the nutritive value of corn meal. Contrary to popular opinion, molasses does not improve the digestibility of other foods with which it is fed; it decreases or depresses their digestibility.[1] As a result of his reading and own experiments, the writer desires to repeat previous statements concerning the use of molasses: —

1. *For Dairy Stock.* — No advantage is to be gained by northern farmers from the use of molasses as a food in place of corn meal and similar carbohydrates. As an appetizer for cows out of condition, and for facilitating the disposal of unpalatable and inferior roughage, 2 to 3 pounds of molasses daily undoubtedly would prove helpful and economical.

2. *For fattening Beef Cattle.* — Some 3 pounds daily may be fed advantageously, especially during the finishing process, when the appetite is likely to prove fickle. The object at such times is to make the food especially palatable, and thus induce a maximum consumption, and also to secure a bright, sleek appearance.

3. *For Horses.* — In spite of the many favorable reports relative to the use of molasses, the writer is not inclined to recommend to northern feeders its indiscriminate use in the place of the cereals and their by-products. As an appetizer and tonic for horses out of condition, and for hard-worked horses, as a valuable colic preventive, and for improving the palatability of rations, 2 to 3 pounds daily of molasses undoubtedly would prove productive of satisfactory results. Frequently, however, horses that have become accustomed to molasses as a component of the ration refuse to eat freely should the molasses be removed.

(6) *How to feed Plain Molasses.*

When molasses is fed in its natural state it should be warmed if necessary, diluted somewhat with warm water, and mixed with the bulk of the grain ration or with finely cut hay or straw. Molasses may also be placed in a sack suspended in a barrel of water over night and the resulting liquid given as a drink.

2. COTTONSEED MEAL AND COTTONSEED HULLS.[2]

Cottonseed meal is the ground cake resulting from the extraction of cottonseed oil from the cottonseed kernel. Cottonseed meal containing not more than 8 per cent. fiber nor less than 40 per cent. protein is to be preferred to that containing more fiber and less protein. Our compilations of analyses of cottonseed meal made since the adoption of the feedstuff law show the following average protein, fat and fiber content for the various years: —

[1] Mass. Expt. Sta., 22d report, pp. 82–131.

[2] Prepared entirely by Mr. Smith.

Year.	Number of Samples.	Protein (Per Cent.).	Fat (Per Cent.).	Fiber (Per Cent.).
1897–1902,	93	46.2	11.2	5.8
1902–1906,	190	45.4	9.6	6.4
1906–1911,	85	42.0	9.2	7.3
1911,	30	41.0	8.2	7.7
1912,	64	41.0	7.7	8.4
1913,	87	40.2	7.7	9.2
1914,	50	40.2	7.6	9.4

There is a growing tendency to incorporate more hulls in cottonseed meal, as is clearly demonstrated in the gradual and consistent increase in the fiber content of the meals collected during the last seventeen years. The preceding average does not show the worst samples, as a number of those collected during 1914 contained as high as 12 per cent. of fiber.

Cottonseed meal has long been considered the most economical and satisfactory protein concentrate that the New England dairy farmer could buy, and its value has been set forth by experiment station officials and practical feeders. If it is to continue to hold its high place this gradual decrease in its quality must stop.

Bartlett has demonstrated in a very striking manner the wide difference in the feeding value of cottonseed meal containing different proportions of fiber or hulls by actual digestion tests with sheep, as follows:[1] —

(1) *Composition of Four Grades of Cottonseed Meal used in Digestion Experiments.*

Grade.	Water (Per Cent.).	Ash (Per Cent.).	Protein (Per Cent.).	Fiber (Per Cent.).	Nitrogen-free Extract (Per Cent.).	Fat (Per Cent.).
Very high,	8.01	7.59	46.75	6.23	21.64	9.78
Dark colored,[2]	12.72	7.05	42.50	7.67	14.64	8.62
Medium,	11.60	6.50	34.13	13.58	19.83	8.90
Low,	9.52	4.70	23.81	21.43	30.53	6.20

[1] Bul. No. 115, Maine Experiment Station.

[2] Due to fermentation.

(2) *Digestion Coefficients with Sheep.*

Grade.	Dry Matter (Per Cent.).	Organic Matter (Per Cent.).	Protein (Per Cent.).	Fiber (Per Cent.).	Nitrogen-free Extract (Per Cent.).	Fat (Per Cent.).
Very high,	90.0	95.3	83.3	–	95 9	100.0
Dark colored,[1]	85.8	89.9	82 2	–	94.7	97.2
Medium,	73.0	78.0	83.6	43.5	82.1	94.6
Low,	61.4	64.1	72.6	37.8	67.8	90.1

[1] Due to fermentation.

Pounds of Digestible Nutrients in 100 Pounds of the Different Grades of Cottonseed Meal.

Grade.	Organic Matter (Pounds).	Protein (Pounds).	Nitrogen-free Extract (Pounds).	Fat (Pounds).
Very high,	80.4	39.0	20.8	9.8
Dark colored,[1]	72.2	35.0	13.9	8.4
Medium,	63.9	28.5	16.3	7.3
Low,	55.0	17.3	16.5	5.6

[1] Due to fermentation.

It will be seen that 100 pounds of low-grade cottonseed meal contained about 30 per cent. less digestible organic matter than the high-grade material. The addition of hulls to cottonseed meal, even in small amounts, lessens its feeding value in two ways: first, it decreases its protein content; second, it impairs its digestibility. Since the quality of the meal sold in Massachusetts is gradually growing poorer, consumers have a right to know just where this decreasing feeding value is going to stop. Manufacturers claim that it is due largely to improved processes in the extraction of the cottonseed oil.

(3) *Cottonseed Feed Meal.*

Cottonseed feed meal is either a mixture of cottonseed meal and crude hulls or of cottonseed meal and cottonseed hull bran. When the mixture consists of cottonseed meal and hulls it is usually derived from the Sea Island cottonseed, to which no lint adheres, and is theoretically the entire seed (both kernel and hulls) ground together after the extraction of the oil.

Cottonseed hull bran is the cotton hull from which the lint has been removed by a special process. In the preparation of cottonseed for the manufacture of oil the lint is not entirely removed. A number of mills

have been established that take the hulls from the cottonseed crushers and remove the last trace of lint. Only a small proportion of the hulls produced, however, are entirely delinted.

Here follow the analyses of cottonseed hulls, cottonseed hull bran, and cottonseed feed meal made at the experiment station: —

Material.	Water.	Protein.	Fat.	Nitrogen-free Extract.	Fiber.	Ash.
Cottonseed hulls,[1]	11.0	5.3	2.4	39.0	39.7	2.6
Cottonseed hull bran, . .	11.0	2.3	1.1	48.7	35.0	1.9
Cottonseed feed meal,[2] . .	10.3	21.3	4.9	39.8	19.0	4.7

[1] This analysis was made in connection with some experimental work at the experiment station prior to 1900. Owing to improved processes in the separation of meats and hulls, cottonseed hulls now contain less protein and fat than formerly.

[2] Analysis of sample used in digestion experiment.

Experiments have shown about 41 per cent. of the cottonseed hulls to be digested and utilized by ruminants, as compared with 55 per cent. in case of timothy hay. In other words, in 1 ton of material there would be 820 pounds of cottonseed hulls digested as compared with 1,100 pounds of timothy hay. Data are not available for the cottonseed hull bran, but it is not believed its digestibility is much greater. The results of a digestion trial with cottonseed feed meal made at this station follow: —

Digestion Coefficients for Cottonseed Feed Meal.

Sheep.	Dry Matter.	Ash.	Protein.	Fiber.	Nitrogen-free Extract.	Fat.
V., ...	59.30	47.20	73.57	32.31	61.35	102.97[1]
VI., ...	57.15	51.53	76.34	19.88	61.04	98.25
Average, ...	58.23	49.37	74.96	26.10	61.20	100.66
High-grade cottonseed meal for comparison.	79.00	84.00	84.00	35.00	78.00	94.00

[1] This figure simply shows that all of the fat was digested, together with 2 per cent. more of the fat in the hay fed than was digested when the hay was fed alone.

The low fiber digestibility is due to the tough, woody character of the hull. This material contains only about three-fourths of the total digestible dry matter of cottonseed meal of good quality. Furthermore, since it contains much less digestible protein and two and one-half times as much total fiber as genuine cottonseed meal, it is not worth more than one-half as much for animal feeding. At the present time (October, 1914) it is being offered at a price about three-fourths that of choice cottonseed

meal. Judging from its analysis it probably contains 1,000 pounds of choice cottonseed meal and 1,000 pounds of cottonseed hull bran to the ton.

(4) *Conclusions.*

I. On the basis of analyses made during the last seventeen years, it is evident that the quality of cottonseed meal sold in Massachusetts is gradually growing poorer.

II. The addition of cottonseed hulls or cottonseed hull bran to choice cottonseed meal noticeably decreases its digestibility.

III. Cottonseed feed meal, being a mixture of approximately 1,000 pounds of choice cottonseed meal and 1,000 pounds of cottonseed hull bran, does not have much over one-half the feeding value of choice cottonseed meal, while it sells for three-fourths as much.

IV. While cottonseed hulls and cottonseed hull bran can probably be used to advantage in the south, they are not worth the consideration of the northern feeder, either as a product by themselves or as an admixture in good cottonseed meal.

3. COCOA SHELLS.

Cocoa shells are the hard, outside coating or bran of the cocoa bean. They are dark brown in appearance and brittle in texture. They comprise from 10 to 16 per cent. of the bean. The entire residue, however, removed from the bean and included as cocoa shells amounts to from 16 to 25 per cent. The output for the United States has been estimated at 6,700 tons. Up to the present time their use in this country as a feeding stuff has been quite limited, although they are now known to be used in several poultry mashes and in one brand of calf meal. In Europe they are used as a partial food for horses and cattle and as an adulterant for oil cakes. Large quantities are also used by the Swiss as a feed for draft oxen, thus utilizing the residue from their chocolate factories. It is held that they act as a stimulant to the nerves and muscles and enable the animals to do a greater amount of work.[1]

(1) *Chemical Composition.*

Number.	Water.	Ash.	Protein.	Fiber.	Nitrogen-free Extract.	Fat.
A,[2]	4.50	8.43	13.90	12.65	55.61	4.91
B,[3]	10.00	7.40	14.30	15.80	46.30	6.20

[1] Pott, Handbuch d. thierschen Ernährung, etc., 3rd Bande pp. 136–141.

[2] As used in digestion trial.

[3] Kellner's tabulation.

The difference between the American and German figures is within the limits of variations in different samples.[1]

(2) *Digestion Coefficients with Sheep.*

Sheep.	Dry Matter.	Ash.	Protein.	Fiber.	Nitrogen-free Extract.	Fat.
I.,	56.55	13.04	4.41	41.41	75.75	100.44
II.,	58.59	14.32	18.52	59.91	71.16	100.54
Average,	57.52	13.64	11.47	50.66	73.46	100.48
German coefficients,[2]	36.00	–	5.00	21.00	48.00	84.00

It will be seen that the product used by Kellner for some reason was much less digestible than that used by ourselves.

Pounds Digestible in 100 Pounds of Shells.

	Massachusetts.	Kellner.
Protein,	1.53	.71
Fiber,	6.45	3.31
Nitrogen-free extract,	40.60	22.22
Fat,	4.91	5.21
Total,	53.49	31.45

It is quite evident that the proteid matter is only slightly digestible and may be considered a negligible quantity; hence the value of the product consists of the digestible fiber, fat and extract matter. On the basis of his results, Kellner remarks that the cocoa shells have no more feeding value than straw.

The net available energy on the basis of our own digestion trials is 63 as compared with corn meal equal to 100. When, however, one considers their non-palatability and their rather objectionable appearance, together with the results of other investigations, it does not seem advisable to rate them as having more than one-half the feeding value of corn meal.

(3) *Feeding Trials.*

A number of milch cows were fed from 2 to 3 pounds, daily, of the cocoa shells, both ground and unground, mixed with other grains. One cow was induced to eat as high as 5 pounds when mixed with malt sprouts and

[1] Foreign workers have shown the presence of the alkaloids caffein and theobromine, also a considerable percentage of pentosans. Fowler, in the laboratory of the Massachusetts Agricultural College, has determined the percentages of the alkaloids, and has found also 8.3 per cent. of pentosans, 7.3 per cent. of galactans, a little over 1 per cent. of starch and traces of sugar.

[2] Obtained by Kellner.

corn meal. It was difficult to induce the animals to eat the shells unground. It was not possible to make any comparative tests of the effect of a definite amount of ground shells upon milk production, as compared with some other grain, for the reason that a sufficient number of animals was not available at the time. The observation simply indicated that the animals would eat the ground shells when mixed with other grain.

(4) *Manurial Value.*

The average of two analyses of cocoa shells showed them to contain: —

	Per Cent.
Nitrogen,	2.45
Potash,	2.92
Phosphoric acid,	.69

The nitrogen was found to be about one-third available. The balance would, of course, be of use to plants from year to year. Based on the above analyses the shells have a commercial value of about $6 a ton as a fertilizer.

(5) *Conclusions.*

The results of our study of cocoa shells show them to have a feeding value about one-half as high as corn meal. They are best suited for dairy animals, while in foreign countries they are used also as a partial food for horses. Dairy animals will, as a rule, not eat them unground. If they can be had at a sufficiently low price the ground shells can be used in amounts of from 1 to 3 pounds daily mixed with the grain ration. Because of their low digestibility it is doubtful if they can be purchased to advantage as a food for horses. As a source of fertility they are evidently not worth much more than the cost of cartage and spreading. They may also be used for bedding purposes.

4. WHEAT OR GRAIN SCREENINGS.

Grain screenings consist of the light seed, weed seeds, chaff and dirt separated from grain in the process of winnowing. The composition of grain screenings depends upon the kind of seed from which they are separated and upon their freedom from dirt and chaff. They necessarily vary so much in composition that no general statement as to their value can be made. Where screenings contain a large amount of straw and chaff they cannot be considered much superior to straw; on the other hand, screenings free from chaff and dirt, and containing nothing but light grain and weed seed, possess considerable feeding value.

Grain screenings are but little used by themselves as a feeding stuff in Massachusetts, but are found on the market as a component of molasses feeds, of wheat by-products, and occasionally of the so-called stock feeds. In the west screenings have been used for fattening sheep. Formerly one

objection to the use of screenings in proprietary stock feeds was due to the fact that they contained many whole weed seeds which passed through the animal undigested and found their way on to the land ready to grow, and thus added to the labor of keeping cultivated land free from weeds. With improved processes of manufacture the screenings are now mostly finely ground and their germinating property destroyed.

(1) *Physical Appearance.*

Two lots of screenings were obtained from a commission merchant in Milwaukee. They were quite similar in physical appearance. The following materials were identified in sample No. 1; light oats, oat hulls, wheat, wheat refuse, smutted grain, yellow foxtail, green foxtail, corn cockle, bindweed, flax, lady's thumb, charlock, wild mustard, rape, lamb's-quarters, large smartweed, chaff of various sorts, wild sunflower, pigweed, timothy, shepherd's-purse, chess, oat grass, wild oats, rye and corn, together with a few unidentified seeds. Both lots used must be considered as of good quality for screenings, as they did not contain excessive amounts of broken straw, chaff or dirt.

(2) *Chemical Composition.*

Sample.	Water.	Ash.	Protein.	Fiber.	Nitrogen-free Extract.	Fat.
No. 1,	8.0	4.9	15.6	9.1	54.7	7.7
No. 2,	11.5	3.8	15.5	7.3	57.2	4.7
Wheat bran for comparison,	10.0	6.2	16.1	10.0	53.3	4.4

(3) *Digestion Coefficients obtained with Sheep.*

Lot I.

Sheep.	Dry Matter.	Ash.	Protein.	Fiber.	Nitrogen-free Extract.	Fat.
V.,	57.57	27.36	78.88	-	63.76	86.18
VI.,	60.65	26.10	82.97	-	65.33	87.41
Average,	59.11	26.73	80.93	-	64.55	86.80

Lot II.

Sheep.	Dry Matter.	Ash.	Protein.	Fiber.	Nitrogen-free Extract.	Fat.
V.,	64.93	-	62.26	-	79.54	87.67
VI.,	68.58	-	63.01	-	84.12	92.50
Average,	66.76	-	62.64	-	81.83	90.09
Average for both lots,	62.94	-	71.79	-	73.19	88.45
Wheat bran for comparison,	66.00	-	77.00	39.00	71.00	63.00

The difference shown in the digestibility of the two lots can probably be accounted for by the fact that the first lot contained more fiber and less nitrogen-free extract than did the second. The fiber contained in both lots did not appear to be at all digestible, indicating somewhat of a depressing effect of the wheat screenings upon the fiber digestibility of the hay, and also that the fiber contained in the weed seeds of the screenings was of decidedly inferior character. In chemical composition and digestibility the screenings did not appear to vary greatly from wheat bran.

(4) *Conclusions.*

The chemical composition and the results of the digestion trials indicate that these particular screenings possessed a considerable nutritive value. Owing to the wide difference in the character of screenings the results obtained should not be considered as representative for all classes of screenings, but only for those reasonably free from dirt, chaff, straw and an excess of noxious seeds. When used either by themselves, or as a component of molasses, wheat or stock feeds, they should be finely ground, and would then approximate wheat bran in the amount of nutritive material they contain.

5. FLAX SHIVES.

Flax shives, sometimes incorrectly called flax bran, consist of the ground refuse stalks and pods of the flax plant. They are sometimes used as a component of stock and molasses feed, and have been found on sale in Massachusetts as a substitute for wheat bran. They have the appearance of finely ground hay. The analysis of two samples at the experiment station showed that this material may vary widely in chemical composition.

(1) *Chemical Composition.*

Sample.	Water.	Ash.	Protein.	Fiber.	Nitrogen-free Extract.	Fat.
No. 1,	6.8	12.1	6.1	45.2	27.7	2.1
No. 2,[1]	10.0	5.0	14.9	32.3	34.9	2.9
Average,	8.4	8.6	10.5	38.8	31.3	2.5

[1] Used in digestion trials.

(2) *Digestion Coefficients obtained with Sheep.*

Sheep.	Dry Matter.	Ash.	Protein.	Fiber.	Nitrogen-free Extract.	Fat.
V.,	42.94	21.86	79.98	22.00	41.27	92.26
VI.,	47.82	23.69	82.08	29.58	45.63	93.09
Average,	45.38	22.78	81.03	25.79	43.45	92.68

This experiment showed flax shives to have a digestibility of about 45 per cent. as compared with 66 per cent. for wheat bran; in other words, 1 ton of flax shives would contain only 900 pounds of digestible matter, while wheat bran contains about 1,140 pounds. Their high fiber content requires considerable extra energy for their digestion. This fact, coupled with their small amount of protein and their low total digestibility, renders them in no way economical for eastern feeders. As a component of mixed feed they must be considered as a filler or adulterant. They may serve, where they are produced, as a partial feed for sheep or steers.

6. MELLEN'S FOOD REFUSE.

This material is sold to a limited extent in eastern Massachusetts and consists of the residue resulting from the manufacture of an infant food. The original ingredients used in this food are malt, flour and bran, the soluble and more digestible parts of these materials going into the infant food.

(1) *Chemical Composition.*

	Per Cent.
Water,	6.98
Ash,	4.07
Protein,	12.57
Fiber,	16.97
Nitrogen-free extract,	55.48
Fat,	3.93

(2) *Digestion Coefficients with Sheep.*

Sheep.	Dry Matter.	Ash.	Protein.	Fiber.	Nitrogen-free Extract.	Fat.
V.,	54.13	–	50.64	42.83	61.85	83.33
VI.,	48.17	–	39.24	46.23	54.87	83.43
Average,	51.15	–	44.94	44.53	58.36	83.38

Pounds Digestible Organic Matter in 100.

Protein,	5.66
Fiber,	7.64
Nitrogen-free extract,	32.18
Fat,	3.26
Total,	48.74

Mellen's Food refuse was found to contain 975 pounds of digestible organic nutrients as compared with 1,140 pounds for wheat bran. Its low digestibility is due, no doubt, to the fact that the more digestible parts of the ingredients used are to be found in the prepared food itself. It has a net energy value of 44.58 therms as compared with 49 therms for

wheat bran, or as 90 is to 100. It could be used as a component of the grain ration for either cattle or horses, providing it could be purchased for substantially three-fourths of the cost of wheat bran. Two to three pounds daily would be considered a normal amount mixed with other higher grade concentrates.

7. CXX FEED.

A by-product known as CXX Feed has been found to some extent on the Massachusetts market. This material bears the name of the Postum Cereal Company, and is supposedly the insoluble residue of Instant Postum, prepared by roasting a mixture of wheat, wheat bran and molasses.

(1) *Chemical Composition.*

	Per Cent.
Water,	9.18
Ash,	2.49
Protein,	17.77
Fiber,	16.45
Nitrogen-free extract,	51.28
Fat,	2.83

(2) *Digestion Coëfficients with Sheep.*

Sheep.	Dry Matter.	Ash.	Protein.	Fiber.	Nitro-gen-free Extract.	Fat.
V.,	45.73	-	19.85	20.00	64.97	77.26
VI.,	40.08	-	19.76	6.76	59.98	78.53
Average,	42 91	-	19.81	13.39	62.48	77.90

Pounds Digestible Organic Matter in 100.

Protein,	3.52
Fiber,	2.21
Nitrogen-free extract,	32.04
Fat,	2.20
Total,	39.97

The results of the experiment show the CXX Feed to have a very low digestibility, probably due to the roasting that the product undergoes, and to the fact that much of the very digestible soluble carbohydrates has been removed. The protein and fiber appear to be of little nutritive value, and the material as a whole must be pronounced quite inferior for feeding purposes.

THE TECHNICAL DESCRIPTION OF APPLES.

BY J. K. SHAW.

Introduction.

This paper aims to set forth certain methods and terms which the writer has found useful in the description of apple trees and fruits. It contains little that is new to the pomological world, but is, rather, a compilation of methods and terms of description gathered from many pomologists of our own and former times. This matter has been brought together and arranged in a definite and systematic manner. It is not intended to be complete in itself, but should be used in connection with a good textbook or reference work on systematic pomology.

The best presentation of tree description may be found in Thomas' "American Fruit Culturist." For description of the fruit, Beach's "Apples of New York" and Hansen, in the "American Horticultural Manual" Vol. II., are the most complete and satisfactory. Other books giving helpful discussions, especially of fruit characters, are Waugh's "Systematic Pomology," Warder's "American Pomology" and Robert Hogg's "British Pomology." Among the German works, Lucas' "Einleitung in das Studium der Pomologie" is most complete and useful.

A written description of a variety of apples may be made from one or more typical specimens before the writer, or it may be written from memory or compiled from notes after one has become familiar with the variety. Two kinds of variety description ought to be recognized, — first, a systematic description which takes account of all characters of the tree and fruit which can have taxonomic value, and second, the commercial description, which is a presentation of all the characters and qualities of a variety that are of interest and value to the man interested in the practice of fruit growing. Most variety descriptions belong to the former class, though some give considerable attention to the commercial phase. Commercial descriptions are of much the greater interest and value to the practical orchardist, and they ought to be more clearly recognized and we ought to have more of them. The distinction between the two is an arbitrary one, and is made for convenience and for the sake of emphasizing those qualities that are of paramount interest to the commercial fruit grower.

The Systematic Description.

The systematic description involves all the characters of the tree and fruit having taxonomic value. In the description blank suggested here an effort has been made to classify these characters, and as far as possible to

reduce each to a single unit. Under each heading a single character is to be considered and described, usually with one appropriate word. Rarely will several words be required. In the text and in Fig. 1 descriptive words are suggested. While these are not all that may be required, we believe that additional ones will not often be needed, with the exception of qualifying adverbs. Words such as *very*, *slightly*, *much*, *rarely* and many others will be called into use freely, but it is felt that it is unnecessary to suggest them all through the discussion of the description blank. Where additional terms are used one should be careful that he understands the relation of the new term to those given, and if necessary he should somewhere explain its meaning and relationship. One of the confusing things in fruit descriptions is the use in individual descriptions of different terms with nearly or quite the same meaning, or of a single term with slightly different meanings. Of course, it is impossible to altogether avoid such confusion because apples vary so greatly, but every effort should be made to make things as definite and exact as possible.

In making a systematic description one should state, either directly or by implication, the scope of his description,— whether it is of a single apple, a plate of five specimens, or the variety as it grows over a certain section of the country, as Massachusetts, New England, the Central Mississippi valley or North America. The description of a few specimens is a comparatively simple matter, and may be made in a few minutes by the trained pomologist with the specimens before him. The description of a variety as it grows over a considerable area is more complicated, and can be made only after a thorough study of the behavior all over the district comprehended in the description. In such descriptions we should strive to describe the type of the variety, but as a variety may vary greatly if a district of any size is considered, it becomes very desirable to delimit as well as we can the range of variation. Perhaps the best method to pursue is to give the type and follow it immediately by a statement of the variation. Thus we may describe the form of the Ben Davis for North America as "*roundish-conic*, varying from *oblate-conic* to *oblong-conic*," and other characters in a similar fashion.

Of course such a description will be cumbersome, and for many purposes an abridged form may be found sufficiently complete and more acceptable. Nevertheless, for a thorough college course in systematic pomology, or for exact descriptive work in experimentation, this type of description ought to have a place.

In the description of the individual tree or fruit the location or source should always be given, and if possible the soil and cultural conditions under which it was grown. It is well to give the date on which the description was made, and of course the name of the person responsible for the work.

Tree Description.

Tree. — In the systematic description of the tree the first thing stated is its age. If not definitely known it should be estimated. The next point is the size which may be *small*, *medium* or *large*. This should of course be

Variety From Soil

Tree, age size *small, medium, large* vigor *weak, strong, moderate, very strong*

form *flat, round, oval, upright, spreading, drooping* density *dense, medium, open*

Shoots, length *short, long, medium* size *stout, medium, slender* direction *upright, drooping, diverging, ascending, spreading, regular*

straightness *straight, zigzag* curvature *curved, not curved* internodes *short, medium, long*

Bark, color *green, yellow, orange, red* scarf-skin

surface *shining, medium, dull* thickness *thick, medium, thin* pubescence *much, medium, thin, fine, coarse*

Lenticels, number *few, medium, many* size *small, medium, large*

form *oval, roundish, flattened* color *white, gray, brown* position *even, raised*

Wood, color *green, yellow* hardness *hard, medium, soft*

flexibility *stiff, medium, flexible* pith *narrow, medium, wide*

Buds, size *small, medium, large* form *roundish, ovate, oval, slender* color *brown, red*

position *free, appressed* surface *pubescent, smooth*

Leaves, Petiole, length *long, medium, short* size *slender, medium, stout*

color *green, red* surface *smooth, pubescent*

Stipules, size *small, medium, large* form *wide, medium, narrow*

Blade, size *very small, medium, small, above medium, below medium, large, very large* form *flat, folded* mid-rib *straight, reflexed*

sides *even, waved, wrinkled, crumpled* outline *oval, ovate, oblong*

base *broad, rounded, narrow* apex *broad, medium, narrow* point *small, medium, large, blunt, acute, acuminate*

general color *light green, dark green* vein color *green, red*

position *erect, spreading, drooping* thickness *thick, medium, thin*

serratures, nature *sharply serrate, serrate, dentate, crenate* direction *strongly forward, forward, outward*

size *small, medium, large* regularity *regular, irregular, double*

curvature *curved, straight* depth *deep, medium, shallow* space *distinct, indistinct.*

surface *dull, shining* texture *coarse, fine* pubescence *short, long, fine, coarse, woolly*

Flower

Characteristics

Described by Date

Massachusetts Experiment Station Department of Pomology

Fig. 1. — Description blank, for the tree, with terms used.

stated in relation to the age of the tree. The size of the tree is determined by the rate of growth in the past, while the vigor measures its current rate of growth as indicated by the length and size of the shoots and the color, size and abundance of the foliage. In vigor the tree may be *weak, moderate, strong* or *very strong.* Next comes the form of the tree which is often characteristic and important in trees that are approaching or have reached maturity. Most varieties begin to take on their characteristic form by the time they are four to six years old. The form of the head may be *flat, round, oval, upright, spreading* or *drooping.* The density of the head is determined by the thickness of its branches and by the abundance of their foliage. It may be *dense, medium* or *open.*

Shoots. — The shoots comprise the last or current season's growth of the more vigorous branches. In very young trees they indicate in some measure the adult form of the tree. Their length should be estimated on the basis of a full season's growth. They may be *short, medium* or *long,* and if the average length in centimeters or inches can be given, so much the better. In size they may be *stout, medium* or *slender,* and if the diameter preferably in millimeters, 2 inches or less above the last annual ring, is given, it adds to definiteness. The direction of the shoots is of special significance in very young trees. They may be *upright, diverging, spreading, drooping, ascending* or *irregular.* The direction may be quite satisfactorily determined by means of a simple protractor. It should be taken on a main branch that is perpendicular. Shoots that are diverging form an angle of about 45°, while ascending shoots are like upright ones, except that they are more distinctly curved near the base. Under straightness we record whether the shoots are *straight* or *zigzag.* In the latter case the successive internodes do not lie in the same direction, but alternate back and forth. Under curvature the shoots may be more or less *curved* or *not curved.* The length of the internodes varies somewhat in different varieties, and they may be *short, medium* or *long.*

Bark. — The color of the bark varies with the season. In the summer it is some shade of *greenish olive* or *yellowish olive,* and the color darkens with the falling of the leaves to a *greenish, yellowish* or *reddish brown.* The full description of a variety ought to include both the summer color and the winter color. The summer color should be taken on wood of the previous season's growth, as that of the current season's growth is apt to be variable. The surface may be *shining* or *dull,* and in thickness the bark may be *thick, medium* or *thin.* The amount of pubescence on the young shoots — *much, medium* or *little* — should be mentioned, and whether it is *fine* or *coarse.*

The lenticels are often characteristic of the variety, and they seem to be quite dependable in identification. The number — *few, medium* or *many* — is most valuable, and should be carefully noted. Their size — *small, medium* or *large* — should find mention, also their form, which is commonly *roundish* but may be *oval* or *flattened.* Their color is commonly *whitish, gray* or *brown.* The position of the lenticels is of especial impor-

tance, and refers to whether they are *raised* above the surface or *even* with it. This is best determined by rubbing gently the surface of the two-year-old wood, or well-matured wood of the current season's growth, with the finger or thumb.

Wood. — The color of the fresh-cut wood will generally be *greenish* or *yellowish.* Experience in pruning or whip grafting will soon demonstrate that varieties vary much in the hardness of their wood. It may be determined — as *hard, medium* or *soft* — by cutting a branch about one-half inch in diameter. The flexibility is judged by bending a small branch thus showing whether it is *stiff, medium* or *flexible.* This character is of practical importance as indicating the danger of the tree breaking under a load of fruit. The diameter of the pith may vary somewhat, and may be said to be *narrow, medium* or *wide.*

Buds. — The buds are best described from near the middle of the current season's growth and during the dormant season of the trees. We note the size, whether *small, medium* or *large;* their form, whether *roundish, oval, ovate* or *slender;* and their color, usually some shade of *brown* or *red.* Their position with respect to the shoot may vary, so that the buds are *appressed* or clinging closely to the shoot, or they may be *free.* The surface may be *pubescent* or *smooth.*

Leaves. — The leaves of different varieties of apples are very characteristic, and offer opportunities for identification almost equal to the fruit, especially if observations can be made during the middle or the latter part of the summer, after the leaves have assumed their characteristic forms. It is necessary to use great care in the choice of specimens for description. Those near or just below the middle of the current season's growth should be chosen. Leaves growing on spurs from older wood should be ignored, as they are apt to be variable and quite unlike those on the free-growing shoots. Upright shoots well exposed to light and air, such as those in the topmost part of the tree, are to be preferred. The leaf is divided into stipules, petiole and blade. The petiole may be *long, medium* or *short,* and in size it may be *slender, medium* or *stout.* The color may be *green,* but usually it is more or less tinged with some shade of *red.* In colored petioles the amount and intensity of coloration increases with the maturity of the leaf. The surface of the petiole may be *smooth* or more or less *pubescent.*

The stipules may be *small, medium* or *large* or especially late in the season there may be *none;* in form they may be *wide, medium* or *narrow.*

In the description of the blade we consider first the size, which may be *small, below medium, medium, above medium* or *large.* In order to establish a standard of judgment of the size of leaves the following measurements of the combined length and breadth are suggested. In taking measurements the leaf should be spread out flat, and the point as defined on page 78 should be ignored.

Combined Length and Breadth.

	Inches.	Millimeters.
Very small,	Up to 4	Below 100
Small,	4–4½	100–115
Below medium,	4½–5⅛	115–130
Medium,	5⅛–6	130–150
Above medium,	6–7	150–175
Large,	7–8¼	175–205
Very large,	Over 8¼	Over 205

Form refers to the relation of the right and left sides of the leaf. If they lie in approximately the same plane the leaf is said to be *flat;* if they bend upward the leaf is more or less *folded.* The midrib may be *straight,* or if curved backward or downward it is said to be *reflexed.* The sides of the leaves may be *even,* or they may be more or less *waved* when there are not over three "waves," and *wrinkled* when there are a greater number. When the surface of the blade is more or less irregular it is said to be *crumpled.* A leaf may present various combinations of these characters. It may be *folded, reflexed* and *even; flat, straight* and *waved;* or it may present other combinations of these characters. Qualifying adverbs indicating the degree to which the leaf is folded, waved or reflexed may be freely introduced. The accompanying plates show characteristic leaves from a number of common varieties. These leaf characters have not been widely recognized, but the writer has found them peculiar to the several varieties and extremely useful in identification; in fact, one may recognize many varieties quite positively by them alone. They are most striking from midsummer until near the time of leaf fall.

The outline of the leaf is usually nearly *oval;* it may be *broad oval* or *narrow oval.* Sometimes it approaches *ovate, oblong* or *roundish.* The base includes the proximal one-third of the leaf, and it may be *broad, rounded* or *narrow,* while the apex includes the distal one-third excluding the point, and may be *broad, medium* or *narrow.*

There is usually a more or less distinct point which may be *small, medium* or *large,* also *blunt, acute* or *acuminate.*

The general color of the normal leaf is always some shade of *green,* usually *light* or *dark;* but may be *grayish, bluish* or *yellowish green.* The vein color is frequently tinged with *reddish* or *pinkish red.* The position of the leaf is its relation to the shoot on which it is borne, and it may be *erect, spreading* or *drooping,* the spreading leaf forming an angle of from 45° to 90° with the branch. Next comes thickness, and the leaf blade may be *thick, medium* or *thin.* The term "serratures" includes all forms of indentation of the margin of the leaf, and their nature may be *sharply serrate,*

serrate or *crenate*, rarely approaching *dentate*. The direction of the serratures is largely indicated by their nature, but it may be useful to make a closer specification on this point, as this is an important one in description. Their direction may be more or less *forward* or, rarely, almost *outward*. The size of the serratures is important, and should be taken strictly in proportion to the size of the leaf and not as to their absolute size. They may be *small*, *medium* or *large*. Their regularity is an important point, and they may be *regular*, *irregular* or *double*.

Sometimes the serratures are distinctly *curved*, in other cases they are *straight*; their depth is closely correlated with size, but it may add to definiteness to specify that they are *deep*, *medium* or *shallow*. Space refers to the amount of separation of the individual serratures; if widely separated they are *distinct*, if set closely they are *indistinct*. In describing the surface and texture of the blade we refer to the upper surface, while the pubescence is found on the lower surface only. The surface may be *dull* or *shining*, the texture *coarse* or *fine*, and the pubescence *short* or *long*, *fine*, *coarse* or *woolly*.

Flower. — The flower presents characters of value in systematic description, but it is available only for a brief period. Apple flowers vary in size and color, in the form of their parts, and probably in other characters. The writer has had so little opportunity to study apple flowers that he hardly feels like attempting any discussion of their exact description. Space is provided in the blank suggested for mention of such points as seem worthy of specific description.

Finally, under the heading "characteristics" we may sum up in a few words the specific characters that serve to distinguish the variety described. Careful study of any variety will usually reveal certain things about the leaves, twigs or general form of the tree that serve to identify it, and a terse recapitulation of these will be found very useful.

Fruit Description.

Size. — In the description of the fruit the first point that we consider is size. This may vary from *very small* to *very large*, or even to *extremely large*. The importance of stating the size in definite units, as inches or millimeters, as discussed on page 87, cannot be too strongly emphasized if exact work is desired. In the opinion of the writer the relation between the descriptive terms suggested and actual measurements of the cross diameter ought to be about as follows: —

APPLE, name

Size { *very small, small; below medium, medium; above medium, large; very large, extremely large* } uniformity { *uniform, not uniform* }

Form { *oblate, globose; ovate, conic; oblong, truncate* } base { *narrow, rounded; broad, flattened* } apex { *conic, narrow, rounded; broad, flattened* }

cross-section { *round, oval, pentagonal* } *regular, irregular* sides { *equal, unequal* } uniformity { *uniform, not uniform* }

Color { *greenish, yellowish* } over-color { *red, crimson, scarlet, pink* } amount, %

disposition { *blushed, streaked, mottled, striped, splashed* } russet { *dense, irregular, thin, scattered* }

Bloom, amount { *much, medium, little* } kind { *waxy, greasy* }

Skin, thickness { *thick, medium, thin* } texture { *tough, medium, tender* } surface { *smooth, rough, lumpy; shining, dull* }

Dots { *conspicuous, obscure, inconspicuous* } number { *many, medium, few* } size { *minute, small, medium, large* } form { *round, stellate, angular, areolar* }

color *white, gray, brown* distribution { *uniform, not uniform* } prominence { *sunken, even, raised, submerged* }

Cavity, depth { *deep, medium, shallow* } breadth { *wide, medium, narrow* } sides { *abrupt, steep, flaring* }

vertical outline { *acuminate, acute, obtuse* } cross-section { *round, oval, triangular, pentagonal* } markings { *russet, none* }

Stem, length { *long, medium, short* } size { *stout, clubbed, medium, slender* } direction { *straight, inclined, curved* } color { *brown, green* } surface { *smooth, pubescent* }

Basin, depth *as with cavity* breadth sides

vertical outline *as with cavity* cross-section { *wavy, ribbed, folded* } markings { *leather, cracked* }

Calyx, *open, closed* size *small, medium, large* surface *smooth, pubescent*

Calyx segments, size { *small, medium, large* } form { *obtuse, acute, acuminate* } position { *connivent, convergent, reflexed* }

Tube, length { *short, medium, long* } breadth { *wide, medium, narrow* } form { *funnel-form, conic* } stamens { *basal, median, marginal* } pistil point { *present, absent* }

ore { *axile, abaxile* } size { *small, medium, large* } position { *sessile, median, distant* } form { *oblate, oval, roundish, oblong, ovate* } core-lines { *distant, meeting, clasping* }

Cells *open, closed* size *small, medium, large* symmetry *symmetrical, unsymmetrical*

Carpels, form { *elliptical, oblong, ovate, oval, roundish, obovate* } apex { *acute, obtuse, mucronate, emarginate* } surface { *entire, slit, tufted* } concavity { *little, medium, great* }

Seeds, number *few, many* condition { *plump, medium, shriveled* } size { *small, medium, large* } color { *brown, olive, gray* }

cross-section { *roundish, oval, flattened* } longitudinal section { *long, obtuse, acute, short, acuminate* }

Axis, length *long, medium, short* direction *straight, inclined*

Flesh, color *white, yellow, green* texture { *fine, medium, coarse; buttery, melting, firm, breaking, crisp* } juice { *little, medium, much* }

Flavor *acid, sub-acid, sweet* quality { *poor, medium; good, very good; excellent, best* }

Remarks

Specimens from Described by Date

Massachusetts Experiment Station Department of Pomology

FIG. 2.—Description blank for the fruit, with terms used.

	Inches.	Millimeters.
Very small, ...	Below 1⅜	Below 35
Small, ...	1⅜–2	35–50
Below medium, ...	2–2⅜	50–60
Medium, ...	2⅜–2¾	60–70
Above medium, ...	2¾–3⅛	70–80
Large, ...	3⅛–3⅝	80–95
Very large, ...	3⅝–4¼	95–110
Extremely large, ...	Over 4¼	Over 110

The measurements in inches are not in all cases exactly the same as the corresponding ones in millimeters, but it seems wiser to adhere to the use of less complicated fractions, even at a slight sacrifice of accuracy. The Siberian crabs should be considered in a class apart, and the above measurements will not hold for them. Probably most pomologists would give some consideration to the axial diameter in connection with size, but it is certainly of less importance than the cross diameter, and it would seem that the minimizing of such consideration would render descriptions simpler and more exact. The relation of the two diameters is brought out clearly in the description of form. Some varieties will run quite uniform in size, while others are more or less variable. This may be appropriately described under uniformity in size.

Form. — Pomologists are agreed that the form of a variety is most important, and therefore it should be described with care. In the present outline, under the term "form," is described only the general form of the fruit, leaving some of its divisions for consideration under the subheads. The form may be described as *oblate*, *globose*, *ovate*, *conic*, *oblong* or *truncate*. It is commonly said that an apple is oblate when the axial diameter is less than the cross diameter, and this is amply true; but when it is further said that in a globose apple the two diameters are equal, it is not true, if the actual measurement of the apple is considered. It may appear so to the eye, but owing to the indentation of the cavity and basin the cross diameter of such an apple is much the greater. Where the two are equal the apple would often be called oblong. For the reason given above the impression through the eye, which sees the general outline of the apple only, ignoring the flattening of the base and apex, and the actual measurement are unlike. The term "roundish" is commonly used instead of globose, but to us the latter seems the more exact and desirable term. The use of combinations of the terms given, such as *oblate-conic*, and of qualifying adverbs is often desirable and helpful.

After describing the form of the apple as a whole, special consideration is given to the base and the apex, the former comprising about one-third of the stem end, and the latter about one-third of the blossom end, of

the apple. Each of these may be *conic*, *narrow*, *rounded*, *broad* or even *flattened*.

The cross section should be taken midway between the ends of the apple and at right angles to the axis. Two questions are to be answered under this heading — the first, whether the general outline approximates a circle, in which case it is said to be *round*, or if the apple is compressed, when the cross section will be *oval;* the second question is whether the outline is *regular*, *irregular* or *pentagonal*. Commonly, one cheek of an apple develops more fully than the opposite one, due apparently to better exposure to the sunlight, in which case the sides are said to be more or less *unequal*. As with size, we may find much or little uniformity in form within a variety. If a single specimen is being described no entry can, of course, be made under uniformity.

Color. — In the description of color a sharp distinction ought to be made between the greenish or yellowish ground color and the reddish over-color, for they are entirely different in their nature and significance. The former, designated simply as color, is some shade of *green*, *yellow* or, rarely, almost *white;* the latter is generally defined as some sort of *red*, either as *light* or *dark*, though some may prefer to consider red as a generic term and use in description such terms as *scarlet*, *crimson*, etc. The amount of over-color should be stated in the percentage of surface covered, and if more than one specimen is considered two numbers should be given, one representing the poorest and the other the best colored specimens. The disposition of the color is likely to be characteristic. It may be evenly spread over the fruit, in which case it is said to be *blushed*, or it may be unevenly disposed, *streaked*, *striped* or *splashed*, according to whether the markings are long and narrow, extending over nearly the whole cheek of the apple, of medium length or short and broad. Combinations of streaks, stripes and splashes often occur, and almost always with one or more of them there is interspersed other coloration that may be disposed irregularly and is said to be *mottled*, so that often an apple is *striped*, *splashed* and *mottled*, and on the sunny side the color may deepen to a *blush;* that is, the stripes and splashes are obscured by the higher development of color over the whole cheek. In naming colors or kinds of distribution it is best to always give them in order of abundance, giving the prevailing kind first. Russet may appear over the whole fruit or in the cavity only. In the latter case it finds mention under cavity markings, while in the former case it is described under russet as *dense* or *thin*, or it may be *irregular*, especially if it is not normal, but the result of unfavorable environmental conditions.

Bloom. — The amount of bloom is best ascertained by scraping the surface with a sharp knife, and recorded as *much* or *little* and the kind as *waxy* or *greasy*.

Skin. — The judgment of the observer of the thickness of the skin, whether *thick*, *medium* or *thin*, and the toughness, whether *tough*, *medium* or *tender*, are to be recorded under the proper heads. Under "surface" we note whether it is *smooth*, *rough* or *lumpy*, and whether it is *shining* or *dull*,

also the presence of one or more *suture lines*, and the presence and nature of a *scarf skin*.

Dots. — The dots are often characteristic and valuable in description or identification. They are always found, and the first question is whether they are *conspicuous, distinct, inconspicuous* or *obscure*. This depends on several factors, such as number, size and color, so we proceed to describe these in turn. The number may be *many, few* or *scattering*. Their size may be *minute, small, medium* or *large*, also the size may be uniform or variable, so that they may be said to be *uniformly large* or *small* to *large*. The form of the dots may be *round, oval, angular, stellate* or *areolar*. Their color may be *white, gray* or *brown*, and the distribution *uniform*, or they may be more or less centered upon the apex of the fruit. Under "prominence" is stated whether they are *raised, even, sunken* or *submerged*.

Cavity. — Under "cavity" we describe first the depth, whether *deep, medium* or *shallow*, then the breadth, whether *wide, medium* or *narrow*, next the sides, whether *abrupt, steep* or *flaring*. The vertical outline, described as *acuminate, acute* or *obtuse*, is practically a repetition of the description of the side, and perhaps one of them might be omitted without loss. If so, we would prefer to retain the former, though the terms given under vertical outline are probably more commonly used. Under "cross section" is given the outline of a section taken about midway of the cavity. It may be *round* or *oval, triangular, pentagonal* or *irregular*. If it has a fleshy protuberance known as a lip it should be here stated. The presence of *russet* should be noted under "markings," and if the russet is *stellate* or *spreading* beyond the cavity it should be mentioned.

Stem. — Following the description of the cavity we naturally consider the stem, — the length, whether *long, medium* or *short*, and the size, whether *stout, medium* or *slender*, also if it is *clubbed*. Next we come to its direction in relation to the axis of the fruit. If it lies in the same line it is *straight*, and if not it is *inclined*, in which case it may or may not be *curved*. Next we have the color, usually some shade of *brown* or *green*, and the surface, which is *smooth* or *pubescent*.

Basin. — In the description of the basin much the same terms may be used as with the cavity, but it should be noted that the basin is formed differently from the cavity, so that the descriptive terms have a different significance, that is, the basin is always much broader at the bottom, more obtuse, and generally more shallow than the cavity. Some additional terms may be required in describing the cross section, such as *wavy, ribbed* or *folded*. The basin is rarely if ever russeted unless the whole fruit is russet, but occasionally we find a variety that is *leather cracked*.

Calyx. — Under "calyx" it should be stated whether it is *open* or *closed*, then follows the size, *small, medium* or *large*, and the surface, whether *smooth* or *pubescent*. The last is perhaps not an important point, as no marked differences between varieties are likely to be found.

Calyx Segments. — After describing the calyx as a whole we consider the individual segments, — their size, *small, medium* or *large;* their form,

whether *obtuse*, *acute* or *acuminate;* and finally their position, whether *connivent*, *convergent* or *reflexed.* In some varieties, especially in over-developed specimens, they are *separate* at the base.

Tube. — The description of the calyx completes the exterior of the apple, and we come next to the interior, considering first the morphological characters exhibited. The tube length may be *short*, *medium* or *long*, the breadth *wide*, *medium* or *narrow*, and the form *conic* or *funnel-form.* The last term is an awkward one, but we can suggest none more suitable. The stamens are *basal*, *median* or *marginal*, according to whether they are near the inner end of the tube, in the middle or near the outer end. In describing the position of the stamens, only the broad or outer portion of the tube is considered; the narrower inner portion, which makes the tube funnel-form, should not be considered. Thus, "stamen position basal" means near the base or narrow end of a conic tube or of the broad portion of a funnel-form tube. The fleshy base of the pistils often persists, especially in specimens not thoroughly matured, and is noted as *present* or *absent.*

Core. — There seems to be some uncertainty as to the exact meaning of the term "core" as used by different systematic pomologists. We prefer to use it to indicate that portion of the fruit within the core lines. The first space in the blank shown is to describe the relation of the core to the axis of the fruit. If there is no space along the axis, and the axial border of the cells is straight, the core is said to be *axile*, while if the axial border of the cells is curved, so as to leave an oval or spindle-shaped space, the core is said to be *abaxile.*

Next is stated the size of the core relative to the size of the whole fruit, as *small*, *medium* or *large*, and then the position, — *sessile* if near the stem end of the fruit, *median* if in the middle, and *distant* if near the blossom end. The form of the core, as indicated by the course of the core lines, usually follows closely the outline of the fruit as a whole, and may be *oblate*, *oval*, *roundish*, *ovate* or *oblong.* Under "core lines" is described their relation to the calyx tube, which may be, rarely, *distant*, more commonly *meeting* or *clasping.*

Cells. — The cells are usually five in number, and the first point considered is whether they have an opening on the side toward the axis of the fruit; if so, they are *open;* if not, they are *closed.* Their size should be considered in relation to the size of the core as above defined, and they may be *small*, *medium* or *large.* If they are of similar size and form they are *symmetrical*, and if not, *unsymmetrical.*

Carpels. — The term "cells" signifies the space enclosed by the carpels, while the latter term means the horny walls, and each carpel is to be considered as a modified leaf. The form of the carpels is likely to be related to that of the core and of the whole fruit. They may be *elliptical*, *oblong*, *ovate*, *cordate*, *roundish* or *obovate.* The apex calls for especial consideration, and may be *acute*, *obtuse*, *mucronate* or *emarginate.* The surface toward the cell may be unbroken or *entire;* it may be marked by trans-

verse fissures or *slit;* or these slits may be covered with a velvety growth, in which case the carpels are said to be *tufted.* The concavity of the halves of the carpels may be *little,* giving a small, thin cell, or it may be *medium* or *great.*

Seeds. — The number of the seeds may be stated as *few, medium* or *many,* and it is always desirable in careful work to give the exact number of seeds. Their condition may be *plump, medium* or *shriveled,* and their size *small, medium* or *large.* Size of seeds should be considered independent of the size of the fruit, and, as elsewhere stated, if the dimensions, preferably in millimeters, are given, it will contribute to the definiteness of the work.

The color of the seeds should be taken only from thoroughly ripe seeds, and is usually some shade of *brown, olive* or *gray.* The cross section, taken through the largest part of the seed, may be *roundish, oval* or *flattened,* while the longitudinal section, taken flatwise of the seed, may be *long* or *short;* also it may be *obtuse, acute* or *acuminate.*

Axis. — Axis length is considered in its relation to the size of the apple, and therefore is related to form and the depths of the cavity and basin. It may be *long, medium* or *short.* The direction is usually *straight,* but occasionally, and usually in the York Imperial, we find the axis *inclined.*

Flesh. — The flesh color is commonly *white* tinged more or less with *yellowish* or *greenish,* and it may be stained in certain parts with *pink* or *crimson.* The texture of the flesh is a very important factor, and may be described as *fine, medium* or *coarse;* also as *buttery, melting, breaking, crisp* or *firm,* the terms being arranged in order. A buttery texture is found only in those apples that break up and dissolve most readily in the mouth, while those with a very firm texture are usually not thoroughly ripened and break up only with some difficulty.

The juiciness of the fruit deserves special mention. It may be *little, medium* or *much.* It may be well to state that juiciness has no relation to the amount of water in the fruit.

Flavor. — Flavor and quality should be sharply differentiated, the former being due largely if not entirely to the relative proportions of sugars, acid and flavoring oils contained in the apple. It may be *acid, subacid, sweet,* according to the ratio of sugars and acid. The presence of an abundance of flavoring oil lends the quality often described as aromatic, but as aromatic relates to odor we prefer to use the word *spicy,* together with appropriate modifying adverbs, where the presence of flavoring oils is evident.

Aroma. — The aroma of an apple is often a means of identification, and it may be described as *none, faint* or *distinct.* If present it may be further described as *pleasant,* or special terms may be devised to suit the peculiar need.

Quality. — The term "quality" is used with a variety of meanings. In this bulletin it is meant to express the summation of the desirability of the apple for human consumption for table or kitchen use, as the case may be. Furthermore, it is the expression of the personal opinion of the individual describing it, and therefore it varies with different persons. There

is no fixed standard for describing quality, and one person's opinion is as good as another's, provided his experience is as wide and his judgment equally sound. Quality is described as *poor*, *medium*, *good*, *very good*, *excellent* and *best*. The judgment of pomologists has been so charitable that "good" has come to signify that the apple under consideration is really rather poor and hardly desirable from the standpoint of quality; the other descriptive terms are similarly reduced from the meaning they have in common parlance.

In most cases one will hardly care to make such extended and minute descriptions as contemplated in the outline discussed above. Where a briefer description is sufficient, and for the student who has mastered these details, a briefer outline may readily be prepared; such briefer description will usually give for each variety those qualities which are characteristic and distinctive of that variety.

The Use of Quantitative Terms.

Where one wishes to do exact work it will increase accuracy to make liberal use of exact measurements; for the novice, especially if he be a student in systematic pomology, it will improve the soundness of his judgment in description, and therefore add to the value of his course of instruction. It takes time and cannot always be undertaken.

Many measurements of the tree characters may be made without difficulty. The height and spread of the tree may be ascertained by direct

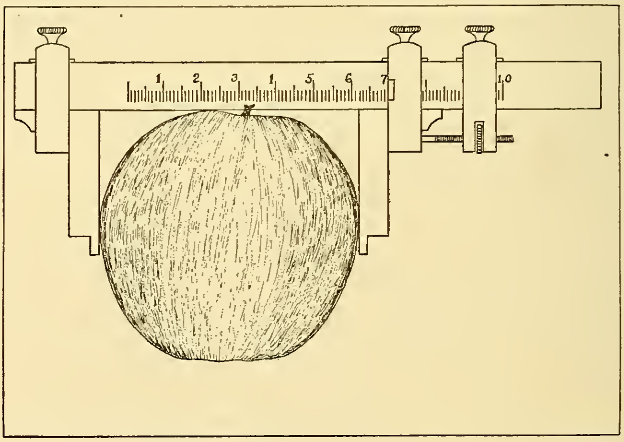


FIG. 3. — Measuring cross diameter.

measurement if the tree is small, or by any of the usual methods of forestry work where the tree is large. The length and diameter of the shoots and buds are easily measured; also the length of the petiole and the length and breadth of the leaf blade. The size of the serratures is most conveniently measured by counting the number per half inch or per centimeter:

An apple fruit seems rather an awkward body to measure accurately; nevertheless, by the adoption of certain fixed rules much can be accomplished. The instruments needed may be a simple ruler, preferably of celluloid, but a pair of calipers is often useful. The unit of measure may be the millimeter or the inch. In itself the former is much to be preferred, but the latter is more commonly used among American pomologists, and doubtless to them conveys a more definite meaning.

The most common and useful measures are the cross and axial diameters. The former should always be taken at right angles to the axis, and the latter parallel with it, and for the sake of a uniform practice it is best to secure the greatest diameter in each case. Calipers are necessary for exact

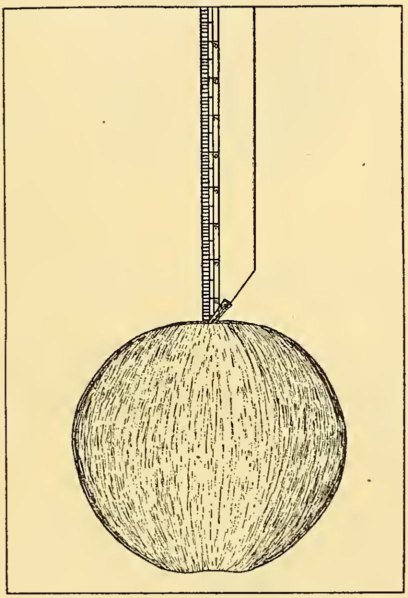


Fig. 4. — Measuring cavity depth.

work, but close approximations may be secured by placing the apple between two parallel surfaces, such as stiff cardboard or a pane of glass and a smooth table top. Of course, if the apple may be cut longitudinally the diameter may be quickly ascertained with a ruler. Care should be taken to cut so as to give its diameters at their longest.

The depth and breadth of the cavity and basin may be measured without cutting the fruit, as shown in Figs. 4 and 5. The rule should be whittled to a dull point about 2 millimeters broad, and the depth ascertained by sighting across the base or apex of the apple, as the case may be. In measuring the breadth the distance between the points of contact of the rule and surface of the fruit is taken. In both cases it is best to take the measure in the deepest and broadest part of the cavity or basin.

There are several characters in the interior of the apple that lend themselves readily to exact measurement. The length and breadth of the tube and of the core, as defined in the text, may be easily measured on cutting the apple longitudinally through the axis; also the length and breadth of

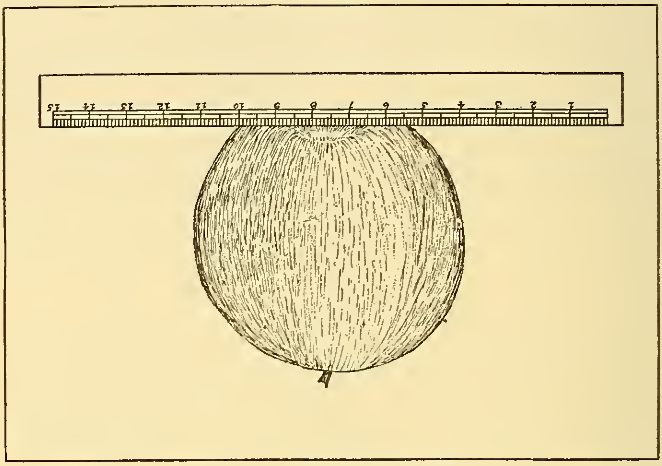


FIG. 5. — Measuring basin width.

the cells, making sure that the cut is made so as to split the cell exactly. The seeds are readily measured, giving their length, breadth and possibly thickness. The axis length from the insertion of the stem to the pistil point is easily measured.

THE COMMERCIAL DESCRIPTION.

A commercial description is quite a different thing from a systematic description. Many systematic characters are included, but their relative importance is changed, and many not mentioned in a systematic description are of the utmost importance. A commercial description of a variety can be made only after a long study of its behavior under varying conditions. Indeed, it would not be too much to say that we possess the knowledge needed for a fairly satisfactory commercial description of only a few varieties, and of these few there is much yet to be learned. Inasmuch as trade conditions are constantly changing, so must the commercial description be amended from time to time.

On the opposite page a blank for making a commercial description is suggested. The size, form and vigor of the tree are to be described as in the case of a systematic description. Under "diseases" should be mentioned such diseases as the variety in either tree or fruit is especially susceptible or resistant to, and so far as possible the degree of susceptibility or resistance. The same applies to the relation of the variety to various insects.

Variety

TREE

Size Form

Vigor

Diseases

Insects

Climatic adaptations

Soil adaptations

Cultural methods

Productiveness, earliness regularity

amount

Nursery growth

FRUIT

Size uniformity

Form uniformity

Color over-color

disposition amount

Skin Cells

Flesh, color texture juice

Flavor Aroma

Quality

Keeping quality Shipping quality

Market value

Remarks

Described by Date

Massachusetts Experiment Station Department of Pomology

FIG. 6. — Blank for commercial description.

Under climatic adaptations we may indicate the conditions of climate under which the variety succeeds best, or, what is simpler, name the region where the variety flourishes best and attains its highest excellence. Under "soil adaptations" should be given the type of soil and subsoil which offers conditions for the best development of the variety.

Comparatively little has been said about the different methods of cultural treatment suited to different varieties; we are not yet beyond argument over soil treatment for all varieties collectively. Yet who can doubt that varieties differ in this as well as in other respects, and that the ideal cultural treatment for one variety may be quite wrong for another sort. Space for this discussion is provided in the blank, and with the accumulation of knowledge along this line it should find expression therein.

The productiveness of a variety is most important, and space is provided for stating if the variety comes into bearing *early* or *late*, and if possible, the age at which it may be expected to begin to bear commercial crops. Under "regularity" is stated whether it is *annual, biennial* or *irregular* in its bearing habit, and under "amount," whether it is a *shy, light, medium, heavy* or *very heavy* bearer. Productiveness, as well as the characters of the fruit given later, depends greatly on the conditions of growth under which the trees find themselves. If we are making a generalized commercial description, it is supposed that the description given is for the variety when growing under conditions of climate, soil and culture favorable to its complete and most satisfactory development. Under nursery growth is given any marked characteristics of the variety as it grows in the nursery row. The behavior of a variety in the nursery has often been the determining factor in its success or failure. Under fruit the various characters are to be described in practically the same way as in the case of a systematic description, but only those characters that are of marked commercial value find space here. We have added the characters of keeping and shipping quality which may be appropriately described.

The market value of a variety is the final test of its commercial worth. Here should be stated the suitability of the variety to the local or general market, and if the latter, the attitude of the great markets of the world toward the variety should find mention.

FIG. 7. — Baldwin × ⅔. Folded, even, straight or slightly reflexed, rather sharply serrate; the serratures strongly forward, often curved, medium size, generally rather deep, not distinct. The peculiar boat-shaped folding and curved, close-set serratures serve usually to identify the Baldwin.

FIG. 8. — Wealthy × ⅔. Slightly folded, slightly reflexed and waved. Very dull serrate or crenate; serratures forward, rather small, medium regular, not curved. The Wealthy is distinguished by its waved leaf, dull serratures and rather coarse texture.

Fig. 9. — Rhode Island Greening × ⅔. Flat, straight or reverse curved, almost even, sharply serrate; serratures well forward, large, irregular, often tending to doubleness, not curved, deep and distinct. The sharp, distinct serratures are useful in identifying this variety.

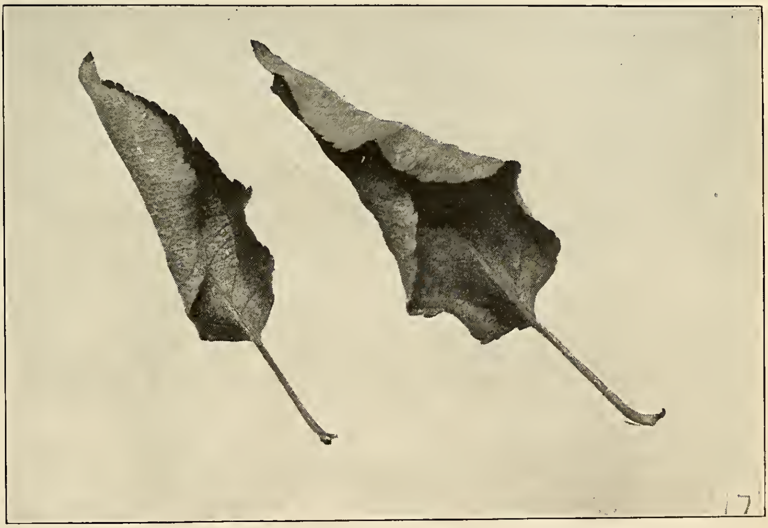


Fig. 10. — Jonathan × ⅔. Very small, strongly folded, sometimes reflexed, waved, dull serrate; serratures well forward, medium or rather small; irregular, often curved, shallow, rather indistinct. The small size, dull serrations, soft texture and strong folding serve to distinguish the Jonathan.

Fig. 11. — Ben Davis $\times \frac{2}{3}$. Small, folded, somewhat reflexed, waved, dull serrate or crenate; base narrow; serratures moderately forward, small, quite regular, somewhat curved, shallow. Ben Davis may be known by its distinct waving, narrow base and dull, shallow serratures.

Fig. 12. — York Imperial $\times \frac{2}{3}$. Medium size, partly folded, reflexed, nearly even, dull serrate; serratures forward, large, irregular, rather deep, quite distinct. York Imperial may be known by its peculiar dull serrate, partly folded, spreading leaves.

Fig. 13. — Hubbardston × ⅔. Small, folded, strongly reflexed, somewhat waved, dull serrate; serratures slightly forward, rather small, fairly regular, moderately deep, distinct. Hubbardston leaves may be known by their small size, peculiar dull serratures, folding, strong reflexion of the midrib and peculiar gray color.

Fig. 14. — Northern Spy × ⅔. Partly folded, slightly reflexed, waved, serrate. Serratures well forward, medium or below, fairly regular, slightly curved, rather shallow, quite distinct. Northern Spy leaves not are easy to distinguish from several related varieties. Their peculiar folding, rather sharp serration and narrow apex serve to distinguish them from most varieties.

REPORT OF CRANBERRY SUBSTATION FOR 1914.

BY H. J. FRANKLIN.

The year's investigations have been along lines previously followed, except that the work with bees was discontinued and studies of the seasonal development of the cranberry root system and of the passage of water through peat were begun.

Weather Observations.

Records of conditions at the station bog were made as in previous years, and minimum temperatures at other locations were also recorded, together with whatever scattering data seemed to be of interest. The readings of the maximum and minimum shelter and bog thermometers and the amounts of precipitation were telegraphed to the office of the United States Weather Bureau at Boston during the periods of frost danger. Thermometers for taking soil temperatures were obtained, and records of those temperatures and their changes under different conditions were begun. The cranberry growing season as a whole was a cool one, there being more frost than usual, especially in September, and also much cloudiness throughout the summer. This caused the crop to ripen fully two weeks later than usual.

The total precipitation was distinctly below normal in spite of the unusual amount of cloudiness, and the beginning of the frost period in September found the ground rather unusually dry. The first cold night came on September 9, and was followed by nine others in succession. On some of these nights the minimum temperature at the low land thermometer near the station bog was 22° below the early evening dew point. Never before, by several degrees, had the station records shown any such difference under such general weather conditions. In the opinion of the writer, this extremely low temperature in comparison with the dew point was due mainly to an unusual lack of moisture in the ground. The difference between the minimum readings of thermometers on the station bog and on low land immediately adjacent was only 2° on the night of the 9th, and there was no difference the following night (10th). The temperatures were not compared on the 11th and 12th, the bog being flooded. On the 13th, the low land ran 6° colder than the bog minimum. As the bog was flooded again on the 14th, the next comparison was made on the 15th, when there was found to be a difference of 5½°. Never before in the records of four seasons had there appeared such a difference in the minimum temperature of these two locations unless the bog was flooded, — a fact which seemed to require explanation. As this difference did not

occur until after the bog had been reflowed (no reflowing whatever had been done between June 26 and September 11), it seems probable that the effect of the flooding partially remained with the bog in some way in nights following those in which the flowing was done. Before the flooding, both the sand of the bog and the adjacent low land were unusually dry. The flooding left the bog in a condition of normal moisture, while the low land remained abnormally dry. This was apparently all that could have had any effect on the difference in temperature between the two locations. It seems evident, therefore, that moisture in the soil tends to maintain a higher air temperature above it on cold nights than would be had without it. That this is true is borne out further by the records of the latter part of September and the first part of October. On the 16th, the difference in the minimum temperature of the two locations — above mentioned — was 4½°; on the 17th, 3° (possibly so little because of failure of one thermometer to record properly); on the 18th, 4°; on the 20th, 6°; and on the 30th, 5°, these dates being selected because their nights alone were cold. Before any October records were made, over half an inch of rain fell, which, of course, did much to bring the soil of the low land back to a normally moist condition. After this rainfall the difference in the minimum temperature between the bog and the low land ranged from 1½° to 3½°, being distinctly less than it was before the rain came.

Acting on the suggestion obtained from these observations, that an increased water content of the soil tends to raise the minimum air temperatures above it on cold nights, the writer had two circular grassy areas (of between 2 and 3 square rods each) covered to an average depth of 6 inches with as dry sand as could be obtained in any quantity, between September 20 and 25. A Green minimum thermometer was placed over the center of each of these areas. On the nights of both September 26 and 27, these thermometers showed a difference of half a degree in their minimum readings. On September 28, the spot which had showed the lower minimum temperature on the two previous nights was wet down thoroughly with water, the wetting being done between 10 A.M. and 2 P.M., the temperature of the water used being 51° (pumped from a driven well 22 feet deep) and that of the sand on the other spot ranging from 51° to 52° at noon. The temperature of the air 6 inches above the center of the spot not wet down was 52° at 11 A.M., and that of the water in the ditches of the station bog at the same time ranged from 53° to 55°. In the cold nights following soon after, the thermometer over the spot that had been wet down recorded a minimum temperature from half a degree to a degree higher than the other one, the result of the test thus corresponding in a general way to that of the observations in connection with the bog and low land thermometers. Great reliance, however, cannot be placed on this result because of the small size of these test areas.

While the results of this investigation are not conclusive, they raise a question of no little importance, for if the moisture content of a soil affects the minimum temperatures of the air above it to any considerable

extent, it is a factor that should be considered in making frost predictions in connection with the growing of cranberries and possibly of other crops also. It should be noted, however, that the results here discussed are at variance with those obtained by Prof. H. J. Cox on the Wisconsin marshes ("Frost and Temperature Conditions in the Cranberry Marshes of Wisconsin," by Henry J. Cox, 1910, Bulletin T. of the Weather Bureau, United States Department of Agriculture, page 61). Professor Cox shows that in comparative studies he obtained the lower temperature readings over the soil containing the greater amount of moisture and states that the increased moisture was "solely responsible for the relative low temperature readings, on account of the heat lost in the evaporation of the surface." The greater specific heat of water, as compared with dry earth, should not, however, be lost sight of in considering this matter.

Frost Protection.

Experiments with cloth, such as is used in growing tobacco under shade, were carried out in September, to see if it could be used satisfactorily in protecting bogs from frost. In these tests a strip of new cloth was supported by wires held 3 feet above the ground by stakes, about 9 square rods of rather dry, grassy low land being covered in this way, the cloth being brought down to the ground to shut in the covered area on all sides. The cloth was spread out for the tests after sundown on cold nights, and was always removed soon after sunrise, so that the ground might be normally exposed to the heat of the sun during the day. Considering the very coarse weave of the cloth, it retarded the rise of heat from the ground to a surprising extent, evidently because the heavy dew that accumulated on it closed its openings considerably. A Green minimum thermometer was placed at the center of the covered area, with its bulb 5 inches above the grass-covered ground, and a similar thermometer at the same elevation, located over grass about 20 feet outside of the cloth, was used for comparison. No frost formed on the covered ground during the tests even when the surrounding low land was white with it, and the thermometers showed that the cloth gave an advantage of more than 4½° in temperature, as shown by the readings in the following table: —

Table 1. — *Effect of Cloth Cover on Temperature.*

Date.	Minimum Temperature (Degrees Fahrenheit).		Wind Velocity (Miles per Hour).
	Area 1.	Area 2.	
September 13, ...	Covered, 31, . .	Not covered, 26½, .	1½ to 4
September 14, ...	Covered, 31, . .	Not covered, 26½, .	6/7 to 1
September 15, ...	Covered, 30⅔, . .	Not covered, 26½, .	3/5 to 1 5/7
September 16, ...	Not covered, 29¾, .	Not covered, 30½, .	No record.
September 17, ...	Not covered, 32⅓, .	Not covered, 32¼,[1] .	No record.

[1] This reading was unusually high, as compared with that over "Area 1," as was shown by numerous readings of these thermometers observed later, but not recorded.

The difference in temperature caused by the use of the cloth might have been greater had a larger area been covered, but the advantage shown in the table would be sufficient to entirely protect a bog in most locations, except under such extreme conditions as would only rarely occur, and even under such conditions it would afford a partial protection. The results of the tests, therefore, appear to highly recommend the use of this cloth for frost protection on bogs which are winter flowed but cannot be reflowed in any way at reasonable expense. It can be purchased in quantity from the manufacturers, all sewed up in strips of any desired size, for 3⅛ cents per square yard, the cost of enough for a whole acre being only about $150, and, if properly cared for, it ought to give good service for many years, as it would seldom be used for extended periods. When used to cover a whole bog, it would have to be spread out on wires in sections and be so arranged that considerable areas could be either covered or uncovered by a single pull of a rope. The first cost of this means of protection fully installed probably would be less than $200 an acre, and the loss by depreciation would be no greater than the cost of the upkeep and operation of a pumping plant. If a grower had to install his protection at less cost than this, he probably could do so by buying cloth that had been used one season in growing tobacco. In the opinion of the writer, the protection afforded by new cloth would be as good as that which would be had with a pumping plant, for such plants frequently fail in emergencies. For strictly dry bogs (without winter flowage) the expense of cloth protection seems prohibitive, because the returns from such bogs are comparatively small.

Fungous Diseases.

These studies were carried on, as in former years, in co-operation with the Bureau of Plant Industry of the United States Department of Agriculture, Dr. Shear having general supervision of the spraying experiments and conducting the laboratory investigations.

Of the various sprayed plots, results with which have been given in previous reports, the following were treated again with Bordeaux mixture on dates as indicated, the neutral copper acetate application given in former years being omitted: A, three times, on June 16, July 20 and August 7; B, three times, on June 16, July 20 and August 8; D, three times, on June 13, July 20 and August 13; "1913," three times, on June 16, July 27 and August 17 (an extra spraying was applied during full bloom to one-half of this plot on July 11); one-half of fertilizer plot 15, three times, on June 16, July 20 and August 8. Plots C and E were left without treatment. The middle half of plot A was fertilized on June 18, a quarter of the plot on each side being left without fertilizer as in the previous season, that used on the middle portion being applied at the following rate per acre: —

	Pounds.
Nitrate of soda,	200
Acid phosphate,	400
High-grade sulfate of potash,	200

The following table shows the total amount of fruit picked from these various plots and from check areas measured out on the bog adjacent to them, as well as the rate of yield per rod in each case, the relative size of the berries, and the per cent. of increase or decrease in fruit production of the plots as compared with their checks: —

TABLE 2. — *Results of Spraying for Fungous Diseases.*

Plot.	Area of Plot (Square Rods).	Variety.	Date picked.	Quantity of Fruit obtained (Bushels).	Quantity of Fruit per Square Rod (Bushels).	Decrease or Increase on Plots (Per Cent.).	Average Size of Berries and Number of Samples examined.
A (middle portion), .	8	Late Howe, .	Sept. 26	9	1.125	23.5[1]	90+3 (6)[2]
A (side strips), .	8	Late Howe, .	Sept. 26	9⅔	1.208	17.8[1]	96+4 (10)
A (3 checks),[3] . .	17½	Late Howe, .	Sept. 26	25⅔	1.470	–	94+4 (5)
B, ...	14⅛	McFarlin, .	Sept. 26	11½	.814	3.2[1]	72+2 (6)
B (1 check), . .	13⅔	McFarlin, .	Sept. 26	11½	.841	–	67+2 (6)
C, ...	16	Late Howe, .	Sept. 26	11⅔	.729	13.2[4]	97+4 (6)
C (2 checks), . .	9	Late Howe, .	Sept. 26	5⅘	.644	–	95+3 (6)
D, ...	16	Early Black, .	Sept. 16	14⅔	.917	3.85[4]	109+11 (6)
D (2 checks), . .	16½	Early Black, .	Sept. 16	14½	.883	–	103+8 (6)
E, ...	16	Early Black, .	Sept. 8	9	.563	10.9[1]	106+11 (6)
E (2 checks), . .	12	Early Black, .	Sept. 8	7 7/12	.632	–	103+5 (6)
"1913,"[5] . . .	{ 4½	Late Howe, .	Sept. 26	5½	1.222	38.39[4]	100+4 (6)
	{ 4½	Late Howe, .	Sept. 26	6⅓	1.407	59.34[4]	100+5 (6)
"1913" (2 checks), .	6	Late Howe, .	Sept. 26	5 3/10	.883	–	100+3 (6)
Sprayed half of fertilizer plot 15, . .	4	Early Black, .	Sept. 16	5⅙	1.292	1.6[1]	104+8 (6)
Other half of plot 15,	4	Early Black, .	Sept. 16	5¼	1.312	–	106+6 (6)

[1] Decrease.

[2] The size of the fruit as shown in the above table was worked out by taking counts of the berries in cupful samples (New England Cranberry Sales Company's inspector's cup), the samples being spread out in a sales company's inspector's hand-grader before the counting was done. When placed in the grader the smallest berries would pass through into the box below, leaving the larger ones to be counted separately. In such formulas as "90+3," given in the table, the first figure shows the average number of large berries, and the second indicates the number of small ones that passed through the grader, the figure in parentheses being the number of samples examined. These samples were examined at the end of the storage tests, and were taken from different boxes as far as possible, so that they might fairly represent the areas from which the berries were picked.

[3] When two or more checks were taken on a plot, as the table shows was generally the case, they were laid out on opposite sides of the plot, and their areas and fruit production were combined in making up the table.

[4] Increase.

[5] The first record given for this plot is for the half sprayed in full bloom, and the other record is for the half which received the three other applications only.

It will be seen at once that, of all these plots, "1913" alone showed a marked increase in the quantity of fruit produced. This plot was sprayed for the first time in 1913, and the results obtained with it in this second year of spraying agree, in a general way, with those obtained in 1912 with plots A, B, C, D and E, they then having been sprayed only one year before. Moreover, the increase was marked, though considerably reduced, even on that portion of the plot which had been sprayed during

full bloom. The reason for this increase in the second year of spraying is obscure, but the fact that it takes place is interesting. The fact that the sprayed half of fertilizer plot 15, which was also sprayed for the first time in 1913, did not show an increase in fruit production is contradictory, but the fertilizer used on this plot may have made the difference.

All the other plots treated this year, except D, produced less fruit than their checks, and D showed only a slight increase. The untreated plot C produced distinctly more fruit than its checks, while E showed a decrease almost as great; the results with these two plots thus being contradictory and not sufficiently marked to be of any apparent value. As all the plots produced much less fruit in 1913 than did the surrounding portions of the bog, they should all, under normal conditions, have shown a distinct increase in 1914 because of their partial rest from fruiting. That they did not do so is good evidence that the spraying was not particularly beneficial and perhaps indicates injury from it.

The smaller the berries the greater the number it took to fill the cup, and if the table is examined with this in mind it will be seen that all of the plots, except "1913," the sprayed half of fertilizer plot 15 and the middle portion of plot A, produced distinctly smaller berries than did their checks. The fertilizer accounts for the exception with plot A and probably also with plot 15; "1913," as already indicated, was an exceptional plot because of its having been sprayed only one season before 1914. The size as well as the quantity of the fruit on these plots seems, therefore, to indicate that general spraying is not a good practice.

The spraying on all these plots was done with a 30-gallon wheeled-barrel outfit, the mechanical injury to the vines not being very great as a long hose was used and the outfit was in no case taken onto either the sprayed areas or their checks. The berries were all picked with scoops and measured in selected boxes of approximately the same size, the loose vines being carefully removed by hand.

The keeping qualities of the fruit from these plots and their checks were tested, the period of storage extending from November 3 to December 30 with the late berries, and from November 14 to New Year's with the Early Blacks. As in the 1913 tests, the berries were carefully measured in every case. The results of these tests were not definite enough in any respect to be satisfactory, perhaps because they were begun too late or because the berries were run through a separator before they were placed in storage, this not having been done in previous years.

As already indicated, one-half of plot "1913" was sprayed during full bloom to determine whether Bordeaux mixture, made according to Dr. Shear's formula for its preparation for cranberry spraying, would do serious damage if applied at that time. The figures given in Table 2 show that this spraying did injure the blossom considerably, causing a reduction in the crop of about 13 per cent., if we regard the bloom as having been equally abundant on both halves of the plot. As a matter of fact, however, the more heavily blossomed half was purposely selected for this

special spraying, and the reduction caused by it, while not definitely computable, was certainly much greater than the figures show.

Tests of the possibility of controlling fungous diseases by putting copper-sulfate in the flowage were again carried out this year, a solution of the chemical being used in the June reflow on flooding sections 23, 25 and 27 at the rate of 1 part to 50,000 parts of water (1 pound in 6,250 gallons). The treatment was applied after these sections had been completely flooded for seventeen hours, and the water was then held twenty-six hours longer. The sulfate solution was thrown into the water by the cupful and was distributed as evenly as possible over all parts of each section treated. The date of treatment was June 11. The blossom buds were then well developed and they did not seem to be injured by the treatment.

Both the treated and untreated sections were picked with scoops on September 7, the former showing no definite advantage in the quantity of fruit obtained. In the storage tests, however, the berries from the treated sections showed, in every case, a distinctly smaller percentage of loss than did those from the other sections. These results are exhibited more in detail in the following table: —

TABLE 3. — *Effect of Treatment with Copper Sulfate in June Reflow.*

FLOODING SECTION.	Variety.	Area of Plot (Square Rods).	Quantity of Fruit picked (Bushels).	Quantity of Fruit per Square Rod. (Bushels).	Period of Storage.	Quantity stored (Bushels).	Loss in Storage (Per Cent.).
21, . .	Early Black,	21.30	13¼	.622	Nov. 14 to Jan. 1.	3	20.59
22, . .	Early Black,	5.10	2¾	.539	Nov. 14 to Jan. 1.	1	29.41
23,[1] . .	Early Black,	12.80	9⅓	.729	Nov. 14 to Jan. 2.	3	18.63
24, . .	Early Black,	5.00	3	.600	Nov. 14 to Jan. 1.	2	26.09
25,[1] . .	Early Black,	11.60	7⅓	.632	Nov. 14 to Dec. 30.	2	13.97
26, . .	Early Black,	4.50	2½	.555	Nov. 14 to Dec. 31.	1	34.00
27,[1] . .	Early Black,	10.66	7	.656	Nov. 14 to Dec. 31.	2	16.67
28, . .	Early Black,	3.08	1¼	.406	-	-	-
29, . .	Early Black,	10.61	8	.754	Nov. 14 to Dec. 31.	2	23.53

[1] Treated.

The reddened and sickly appearance of the foliage on most of the sprayed plots, mentioned in the report for 1913 (page 41), persisted more or less throughout the season of 1914, especially with the Late Howe plots, even where the spraying was discontinued this year. The reason for this apparent injury to the sprayed areas was carefully sought, the condition of the root systems of the sprayed and unsprayed vines being given particular study, as such an investigation seemed to promise the most ready

solution of the problem. The roots were first examined late in May. It was soon found that new rootlets were developing in connection with the unsprayed vines all over the bog. On the sprayed plots, however, there was almost no new root development. It was also noticed early in the season that there was a rather scanty growth of old rootlets near the surface of the sand on the sprayed areas, while on untreated parts of the bog this growth was evidently much more abundant. Moreover, the rootlets near the surface on the plots appeared to be blackened and rather lifeless, as though injured by burning. In June and July the difference in the condition of the roots of the sprayed and unsprayed vines was rather striking. It could be most easily observed by grasping single vines between the thumb and forefinger, close to the surface of the sand, and pulling them up by the roots. When this was done, it was apparent at once that there was no considerable mass of rootlets on the sprayed vines for about an inch below the surface of the sand, while on those that had not been sprayed the rootlets were usually massed close up to the very surface. This condition of the roots seemed to suggest that they had been injured by the spraying in some way.

Attention is called, in this connection, to the fact that a New Jersey grower of large experience has informed the writer that he found his vines taking on a similar sickly, reddish appearance after he had been spraying his bog a few years. His vines apparently got into a worse condition than have those on the sprayed plots of the station bog, a considerable dying out taking place among them. The grower, however, laid the trouble to lack of proper plant nutrition, and applied fertilizers containing nitrates. His vines recovered, taking on a normal green appearance, and are now producing satisfactory crops again. His results in this regard seem to be paralleled — to a considerable extent — by those obtained on the station bog with plot A, the middle half of which was fertilized in both 1913 and 1914, as stated in another place. The vines remained green and thrifty on the fertilized part of this plot, while the unfertilized parts took on the reddened appearance that has been described. In both 1913 and 1914, however, the fertilized part of this plot failed to produce anywhere near as much fruit as did the surrounding unsprayed portions of the bog. While it is by no means certain that the New Jersey grower's difficulty was caused in the same way as that on the station bog, the comparison is certainly suggestive.

To get further light on this whole problem, and to determine definitely in what ways spraying with Bordeaux mixture does injury, special spraying experiments were started on small plots, the sprays applied being made up with varying proportions of lime and copper-sulfate, resin fish-oil soap being used with some and being left out with others. These sprays were applied in excessive quantities (25 gallons to the square rod) so that they would soak into the ground and come in contact with the roots thoroughly. If these experiments show that Bordeaux mixture necessarily causes considerable injury to cranberry bogs, general spray-

ing for the control of fungous diseases on the Cape bogs will seem impracticable until some non-injurious substitute for the Bordeaux can be found. Doubtless, some bogs are occasionally so badly infested with fungous diseases that spraying would be advisable even if it did cause considerable injury. Diseases appear to be so much more prevalent in New Jersey than they are on the Cape bogs that spraying should probably be generally adopted there in spite of the possibilities of its doing damage.

The "ring-worm" trouble (commonly so-called by the growers because it was formerly supposed to be the result of some insect's work) was given some study. The vines die in a small patch at first and, the center recovering, the affected area gradually becomes circular. These patches persist for years, the vines on the outer side of the rim dying every season, while recovery takes place on its inner side, the circle thus growing larger yearly and preserving its form if not interfered with by a ditch or some other obstruction. Both Dr. Shear and the writer for some time have believed this trouble to be due to a fungous disease. Insects evidently do not cause it. This year evidence has come to hand which appears to go far toward proving that fungi are at the bottom of the trouble. On Sept. 24, 1910, the writer visited some bogs in Plymouth, belonging to Mr. Henry J. Thayer of Boston, and found them more badly marked with "ring-worm" patches than any other bog he has ever seen. Moreover, it had been with Mr. Thayer a trouble of long standing, for the "rings" varied in size from mere beginnings to circles 25 or 30 feet in diameter. He thought it was caused by some insect, but decided to try spraying with Bordeaux mixture on the chance that it might be a fungous trouble. He sprayed twice in 1911, three times in 1912, three times in 1913, and twice in the present year, before the writer visited his bogs again on July 4. The change since 1910 was very striking, the "rings" having in most cases entirely or nearly disappeared, and no new dying of the vines being apparent. Mr. Thayer thought his spraying had caused the improvement, and it evidently had. His results seem to help prove the character of the "ring-worm" trouble. It should be stated, however, that in all of his spraying after the season of 1911 Mr. Thayer used commercial "Bordo Lead" with a little Paris green instead of straight Bordeaux mixture.

Early in July, a North Carver grower sent in some vines seriously affected by an unfamiliar disease. Specimens were forwarded to Dr. Shear, and he found the trouble was one which had been known for a long time in Wisconsin, but which had never been previously reported from any other cranberry-growing section. The Wisconsin growers commonly call this disease "false-blossom." There is, however, an entirely different trouble known as "false-blossom" (hypertrophy caused by *Exobasidium* sp.) by the Cape Cod growers, and to distinguish between the two, the new disease will be called "Wisconsin false-blossom" in this report. It is characterized by an abnormally profuse branching of the vines and a

peculiar abortion and malformation of the blossoms. The latter do not develop normally in size or color, but are small and greenish. The peduncles do not curve over naturally, but remain straight and become more or less swollen, so that the flowers open facing upward. The blossoms thus affected produce no berries, and the crop is often greatly reduced in quantity when the vines are badly infested.

The vines sent in affected with this trouble came from a bog on which "Metallic Bell" vines from Wisconsin were planted about ten years ago. The discovery of this disease in Carver led Dr. Shear and the writer to investigate its distribution. It was found on five bogs, all in North Carver, the source and center of trouble being evidently, in every case, vines which had come from Wisconsin. On four of these bogs the trouble centered around the "Metallic Bell" variety. The name of the variety causing the trouble in the fifth case is not known. On one bog the disease had apparently spread from the "Metallic Bell" vines and attacked those of the "Late Howe" variety, especially on some new planting, and was also found to some extent on "Nova Scotia Bell" vines. On another it seemed to have spread from the "Metallic Bell" variety to "Centreville" vines to a slight extent. It was least prevalent on the bogs which had usually been run dry during the growing season, those which had been kept wet being very badly infested. It was first observed on one of these bogs five years ago and has apparently been growing gradually and steadily worse. The discovery of the presence of this Wisconsin disease on the Cape may be a matter of much importance. It is evidently a serious disease, and the results of the season's observations strongly suggest that it may be infectious, though it has by no means been proved to be so. Until more is known about it, Wisconsin varieties cannot be planted on the Cape without considerable risk. The discovery of this disease in Massachusetts and the results of our investigation concerning it are especially interesting in the light of the observations regarding it recently published in the annual report of the director of the Wisconsin Agricultural Experiment Station.[1]

Observations in connection with the new disease, spoken of as the "blossom-end rot" in previous reports, have been continued. This disease was again this year the chief cause of decay among "Late Howe" berries in storage. Numerous samples of fruit infected with it were sent to Dr. Shear for laboratory investigation. Its exact place in botanical classification is not yet determined.

Resanding.

The experiments in resanding have been continued, five plots on the station bog having been devoted to this investigation since October, 1912. Two of these plots have not been resanded for six years. The other three have been resanded every year for the last four years. The bog as a whole

[1] Bulletin No. 240 of the Wisconsin Agricultural Experiment Station, June, 1914, p. 54.

was resanded in the fall of 1911 and spring of 1912 and again in the fall of 1914.

The results with these plots in the amounts of fruit produced were not at all conclusive. The results of the storage tests, however, with only one exception, agreed with those of former years in showing that resanding greatly favors fungous diseases.

Fertilizers.

Most of the fertilizer plots on the station bog were given their 1914 application on June 17 and 18. The lime was not applied to plot 11 until July 17, and plot 12 went without fertilizer until the same date because the muriate of potash was not delivered promptly. The plots were picked with scoops on September 16 and 17, no distinct advantage in quantity of fruit being shown by the fertilized areas as compared with the check plots. The berries seemed so uniform in color and most other respects that no records were made except of their quantity and size. Average counts of berries in several cupful samples taken from each of the plots did not show that the fertilizer had distinctly affected their size.

Storage tests, beginning November 14 and ending on New Year's day, were carried out with berries from each of the plots. These tests probably were not as reliable as those of former years because the berries were run through a separator before they were stored. The results, however, seem to show that the nitrate of soda distinctly impaired the keeping quality, though the greater shrinkage of the fruit from the nitrate-treated plots may have been due to a greater loss of water during storage, rather than to increased rotting, the berries perhaps being somewhat more succulent. The year's experience with these plots and their fruit is shown in detail in Table 4.

Plots 1, 5, 9, 13, 17, 21, 22 and 23 are all untreated check plots. The meanings of the fertilizer symbols used in the table are as follows: —

O = Nothing.
N = 100 pounds nitrate of soda per acre.
P = 400 pounds acid phosphate per acre.
K = 200 pounds high-grade sulfate of potash per acre.
L = 1 ton of lime (slaked) per acre.
Kcl = 200 pounds muriate of potash per acre.
$N_{1\frac{1}{2}}$ = 150 pounds nitrate of soda per acre.
N_2 = 200 pounds nitrate of soda per acre.
$P_{1\frac{1}{2}}$ = 600 pounds acid phosphate per acre.
P_2 = 800 pounds acid phosphate per acre.

In combination they mean, for example, as follows: N_2PK = 200 pounds of nitrate of soda + 400 pounds of acid phosphate + 200 pounds of high-grade sulfate of potash per acre.

TABLE 4. — *Effect of Fertilizers on Quantity and Keeping Quality of Cranberries.*

PLOT.	Fertilizer used.	Date picked.	Quantity of Fruit produced (Bushels).	Quantity of Fruit in Storage Test (Bushels).	Loss in Storage (Per Cent.).
1,	O	Sept. 16	9	3	27.45
2,	N	Sept. 16	9½	3	31.37
3,	P	Sept. 16	8⅘	3	20.59
4,	K	Sept. 16	8	3	24.51
5,	O	Sept. 16	6½	3	26.96
6,	NP	Sept. 16	6⅔	3	34.00
7,	NK	Sept. 16	7⅔	3	31.37
8,	PK	Sept. 16	8⅔	3	23.53
9,	O	Sept. 16	6½	3	29.41
10,	NPK	Sept. 16	8⅔	3	33.00
11,	NPKL	Sept. 16	8⅙	3	37.25
12,	NPKcl	Sept. 16	7¾	3	28.43
13,	O	Sept. 16	7⅔	3	22.53
14,	$N_{1\frac{1}{2}}PK$	Sept. 16	10	3	24.51
15,	N_2PK	Sept. 16	10 5/12	3	26.96
16,	$NKP_{1\frac{1}{2}}$	Sept. 16	9	3	27.45
17,	O	Sept. 16	9⅔	3	23.04
18,	NKP_2	Sept. 17	10	3	30.39
19,	$NPK_{1\frac{1}{2}}$	Sept. 17	9	3	25.49
20,	NPK_2	Sept. 17	6⅚	3	31.37
21,	O	Sept. 17	10⅓	3	32.50
22,	O	Sept. 17	10⅘	–	–
23,	O	Sept. 16	6⅓	3	22.22

As some of the 1913 experiments had seemed to indicate that the setting of the blossoms was stimulated and increased to a considerable extent by the application of nitrogenous fertilizers during the beginning of the bloom, special tests to determine this point were conducted this year. Two plots of four square rods each — one "Early Black" and one "Late Howe" — were fertilized on July 3, the former variety being in full bloom and the latter needing about a week longer to reach that condition. The fertilizer was applied at the following rate per acre: 150 pounds of nitrate of soda + 400 pounds of acid phosphate + 200 pounds of high-grade sulfate of potash. The sand with which the fertilizer was mixed to insure even application stuck to the vines considerably, and it was feared that it might injure the bloom more or less, especially that of the more advanced early variety. The fertilizer was soaked into the bog by a storm which began at 6 P.M. on July 6, there having been no previous rainfall whatever since its application. The plots were examined on July 7, and the "Early Black" vines were then found to be somewhat past full bloom, those of the "Howe" variety having not yet quite reached that condition. Table 5 shows the results obtained with these plots. The size of the berries is indicated by the number it took in each case to fill the inspector's cup of the New England Cranberry Sales Company, two samples being averaged for the "Early Black" records and six for the "Late Howe." The smaller the berries the greater, of course, was the number it took to fill the cup, the sizes, therefore, being inversely proportional to the numbers given in the table: —

TABLE 5. — *Effect of Fertilizer on Setting of Fruit.*

Plot.	Area of Plot (Square Rods).	Date picked.	Quantity of Fruit obtained (Bushels).	Quantity of Fruit per Square Rod (Bushels).	Increase (Per Cent.).	Average Size of Berries and Number of Samples examined.
Early Black, . . .	4	Sept. 10	3¾	.937	7.14	125 (2)
Early Black (check), .	4	Sept. 10	3½	.875	-	120 (2)
Late Howe, . . .	4	Sept. 28	6⅘	1.700	26.50	103 (6)
Late Howe (check), . .	8	Sept. 28	10¾	1.344	-	106 (6)

As the table indicates, there was a distinct increase in fruit on the "Early Black" plot as compared with the surrounding bog, though it was much less marked than that on the "Late Howe" plot, probably because of the difference in the development of the bloom when the fertilizer was applied. It will be seen at once that the increase in quantity was in neither case due, to any considerable extent, to an increase in the size of the berries, and that the fertilizer had apparently caused a greater number of blossoms to set and form fruit with both varieties. In storage tests there was slightly more decay among the berries from the "Late Howe" plot than among those from its check. The "Early Black" fruit was not tested in this regard.

Insects.

The insect studies have covered a rather wide range during the year. The flowed-bog fireworm (black head cranberry worm) and the fruit worm both seem to have been much less abundant than usual, the total injury caused by them probably being about the same as in 1913.

In May and June the forest tent caterpillar (*Malacosoma disstria* Hübner) was very abundant everywhere in the cranberry section, and the worms crawled onto the bogs in large numbers. Their operations were watched carefully, but they were never found feeding on the cranberry vines, and their presence on the bogs need never cause concern, for their normal food plants are evidently so different from the cranberry that the latter is not palatable to them.

Cape Cod, in common with many other sections of the country, suffered this year from a rather severe visitation of the army worm (*Heliophila unipuncta* Haworth). It did quite a little damage on bogs here and there, but the cases of great injury appear to have been few. The cranberry is evidently not a favorite food plant with this insect. It usually works on grasses, grains and corn. As it prefers low lying land, however, the moths frequently, in "army worm years." deposit their eggs in quantities on the bogs, and then the vines are attacked because of the absence

or scarcity of grasses. Rarely, however, is a large bog seriously hurt on more than a few sections. The growers probably need not fear this insect in 1915, for it rarely appears in great numbers two years in succession, as its natural enemies soon control it.

The gypsy moth (*Porthetria dispar* L.) is becoming more of a menace every year. Numerous reports of threatening danger from it were received during the season of 1913, and this year it has caused no little damage on bogs in several localities. It is becoming more abundant yearly on the uplands around the bogs in much of the cranberry section. The danger to the bogs themselves, except possibly where water for reflowage is abundant, evidently grows greater in proportion to this upland increase, for while the female moths cannot fly onto the bogs to lay eggs the small worms can readily be blown on by the winds. This insect, therefore, is fast becoming a cranberry problem, and it must be given more attention from now on. The following matters in connection with it need to be determined especially: —

1. In the more serious cases of bog infestation, does the trouble arise from eggs laid on the bog the year before or from small caterpillars blown on by the winds early in the season?

2. Can gypsy moth eggs survive winter flooding, if the water is held until late in May? It is known that they can endure an ordinary winter flowage (until April 1). In case severe bog infestations usually arise from eggs deposited the previous season, knowledge concerning the limit of their ability to endure submergence becomes of prime importance.

3. What is the best time to reflow to destroy this insect? The caterpillars are very hairy and will float for a long time before they die. The larger they are the longer they can probably live in this way. For this reason a bog should probably be flooded as soon after the eggs hatch, or after the worms are found at work, as possible. The insect net which has been recommended for discovering the first stages of the false army worm probably would be useful in detecting the presence of the small gypsy moth caterpillars early in May. When a bog infested with this insect is flooded, the worms usually float ashore alive in large numbers, and must be killed by burning or by spraying with crude oil or kerosene.

The cranberry weevil (*Anthonomus suturalis* Lec.), which occasionally harms a bog by working within the blossom buds and eating out their hearts, thereby preventing blooming and fruiting, did much damage on some bogs in Plymouth in 1913, and also caused some loss in the same locality this year. Heretofore no effective treatment has been known for this insect. Attempts to destroy it by flooding have been uniformly unsuccessful. The results of some spraying done this year under the supervision of Mr. Henry J. Thayer of Boston, in anticipation of injury from this insect, are therefore interesting. Arsenicals ("Bordo Lead" with Paris green) were used while the vines were in bud, some time before any blossoms had opened. The bogs thus sprayed and adjacent unsprayed vines were examined in August. The weevil evidently had done much less damage where the spray had been applied.

The spanworm (*Epelis truncataria* var. *faxonii* Minot), discussed in last year's report (pages 50 and 51), was found to have seriously damaged a bog in Wareham. Growers of large and long experience in the vicinity, when shown these worms, expressed the opinion that this species was the one which used to be so commonly and widely injurious on the Cape bogs. If they were correct in this, as seems most probable, the name "Cranberry Spanworm," given by Dr. J. B. Smith to *Cleora pampinaria* Gn., is more deserved by this species. Caterpillars of this insect were collected on the infested Wareham bog on July 23, 1913. By August 8 many of these worms had pupated, and many pupæ of an Ichneumonid parasite were also found, from 25 to 30 per cent. of the worms apparently having been infested with it. The adult parasites emerged from their pupa cases on dates ranging from June 12 to June 27, 1914. They proved to be a dark-colored species of *Campoplex*, with a broad reddish band about the abdomen. This parasite is new to science, and its full description will soon be published by the writer elsewhere.[1]

The infested Wareham bog was visited again on May 28, 1914, and live pupæ of the spanworm were found under the vines in large numbers. The bog had been winter flowed in December, and the water had been let off on May 10, the pupæ thus having survived a five months' submergence. This confirms the observations in connection with this insect on the Yarmouth bog, where the entirely naked (that is, without any cocoon) pupæ endured flooding for more than four months with but a small percentage of mortality. No moths of this insect were observed on the Wareham bog on May 28.

The "tip worm," the "flowed-bog fireworm" ("black head cranberry worm") and the "fruit worm" are of such importance and so constantly troublesome that our investigations with them deserve special and detailed consideration.

The Cranberry Tip Worm (*Cecidomyia oxycoccana* Johnson).

In 1911, a serious dying of the tips took place on the station bog soon after the vines went out of bloom. Evidently largely as a result of this, the bog did not bud up well for the following season, and the small crop of 1912 (less than 200 barrels) was the result. Until this year the writer thought this tip trouble was secondary to some injury to the root system, caused, perhaps, by mismanagement in the use of water during the growing season. This idea seemed to be substantiated by the fact that dry bogs (without winter flowage) near the station bog showed but little of the tip injury in 1911. The station bog was resanded in the fall of 1911, and the winter flowage was held late (until the 17th of May) the following spring. In 1912, little of the injury occurred on the bog, the bud formation for the following season being almost perfect and resulting in the splendid crop obtained in 1913. In 1913, the injury was again considerable, though the bud development was fairly good, and the 1914 crop

[1] Entomological News, XXVI, 1915. (*Campoplex variabilis* n. sp.).

following those conditions was a fair one. This year the tips died badly, and the budding for 1915 was poor.

The tips have been carefully examined every year since this trouble was first noticed, but the cause of the injury was not discovered with certainty until 1914. The tip worm was suspected from the first, but as the maggots of the broods which appear before blooming time were known to always make their cocoons in the tips of the vines, the cocoons remaining as certain evidence of their work even after the flies themselves had emerged and disappeared, it was thought that at least cocoons, if not maggots, ought to be found in connection with the tip injury coming after the bloom, if it was caused by this insect.

This year a special effort was made to ascertain the cause of the trouble. The tips were examined before they showed injury, while the bog was in full bloom, and maggots in various stages of development were soon found in a good share of them, as many as five sometimes being present in one tip. Tip worm eggs were also found in abundance. In less than three weeks the infested tips had dried up, the maggots having disappeared without leaving cocoons. There was no longer any doubt as to the cause of the injury observed in previous seasons. It was soon found that the maggots of this, the most injurious brood, leave the tips and go down to the sand under the vines to form their cocoons. Unfortunately, it was not discovered in what condition the insect passes the winter. It is suspected that it may remain in the cocoon and be able to endure winter flooding.

As soon as this insect was found in such abundance on the station bog an examination of other bogs was begun, and a great variation was found among them in the amount of tip worm damage, due, apparently, to the treatment they had received. Two-thirds of the tips on the station bog were injured, and practically all of them were hurt on a bog of 4 or 5 acres in Carver. On some bogs, however, the damage was only from 3 to 5 per cent. From 50 to 60 bogs were examined in the course of this investigation, and it resulted in the following conclusions: —

1. That flowed bogs, in case they had not been resanded before the 1st of May, were, as a rule, much more seriously injured than were strictly dry bogs (without winter flowage). In its relative abundance on dry and flowed bogs, the tip worm seems to be in a condition similar to that of the flowed-bog fireworm, though the reasons for the condition may not be the same with both species.

2. That flowed bogs which had been resanded the fall before or in the spring before the 1st of May were, as a rule, much less seriously injured than those not thus resanded. In nearly every case those most hurt had not been resanded for two years or more.

3. The "Late Howe" variety, as a rule, showed distinctly more injury than did the "Early Black."

4. No bog showed great tip worm injury where traces of severe frost damage were in evidence.

5. This seems to have been a year of exceptional tip worm abundance. It is not yet certain why resanding, winter flooding, difference in variety and frost have bearings on the prevalence of this insect. It seems evident, however, that resanding every other year should be recommended as a wise preventive practice against it.

The injury caused by this brood which does its work during the time of full bloom is a matter of great importance. It has undoubtedly been the cause of many a crop failure supposed to have been due to other troubles. Early in October, the tips on the station bog were carefully examined to find out whether there had been much recovery from this injury. It was found that less than half of the injured tips had formed buds for next season. The following count of "Late Howe" tips, made on October 1, showed the most recovery of all the counts made: tips not injured, 39; injured tips which had recovered and formed buds, 31; injured tips which had not formed buds, 34. In many cases the buds on the recovered tips were undersized, and it seemed doubtful if the majority of them were normal. The poor recovery on the station bog may, of course, have been due to a devitalized condition of the vines, but the evidence at hand indicates that this insect is a very serious pest.

The Flowed-bog Fireworm (*Rhopobota vacciniana* (Pack.)).

General observations concerning this insect were made during the year, but no extensive experiments were carried out with it because the tip worm and fruit worm monopolized attention. It seems wise, however, to sum up in this report the possibilities for treating this insect satisfactorily.

1. Where reflowing can be done in June, reasonably effective treatment may be had by using the water according to suggestions and recommendations made in previous reports, and perhaps no improvement in treatment is possible for such bogs.

2. Winter-flowed bogs which cannot be reflowed must either have the flowage held late enough (until, perhaps, June 20) to kill the eggs, as often as an infestation develops sufficiently to do serious damage, the crop being sacrificed in the years of such late holding, or else be sprayed, if any direct treatment is to be applied at all. Arsenical poisons seem to have been pretty thoroughly tested by the growers in practical spraying for this insect. A great advantage is often obtained by their use, but under some conditions the results are very unsatisfactory, and the frequent failures with such treatments have created a general desire for some better method. Only one possibility for great improvement in spraying treatments seems to present itself. Possibly a sweetened spray would be attractive to the worms. Some growers claim to have tried such a spray with exceptionally good results, but it is doubtful if this method of treatment will be found practicable on more extensive trial. Sweetened sprays are nowhere widely used in treating any chewing insect, and if such a treatment were practicable it would probably have come

into extensive use with other insects long ago. Sweetened poison baits have long been widely used against grasshoppers and cutworms, and molasses is commonly used by entomologists to attract many kinds of moths in night collecting. Sweets are, therefore, evidently liked by many insects, and the idea of sweetening arsenical sprays seems worth trying out thoroughly on that account. The fireworm's hatching period, however, often covers several weeks, and, in order to be satisfactorily effective, any poison application must remain on the vines in considerable strength for quite a long time. Sweets being very soluble in water, if used in a spray, will not remain on the vines long if much rain falls. There are, therefore, considerable difficulties to be overcome in making satisfactory use of a sweetened spray.

The outlook, therefore, does not seem bright for treating this insect more satisfactorily by direct methods. It may be possible, however, to treat it indirectly in some way. As stated in previous reports, it does not seriously infest bogs without winter flowage. If infested bogs could be left entirely without flowage, the insect would in time probably be controlled by weather conditions and its natural enemies. If bogs are not winter flowed, however, other troubles have to be met. In the first place, there is the danger of winterkilling, though this factor is not as important as is generally supposed, for severe winter injury does not occur on dry bogs oftener than once in four or five years, and even then the bogs are seldom so hurt that they do not produce partial crops and recover in fair shape for the following year. The fruit worm increase which takes place when winter flowage is omitted is, however, a serious matter, and a satisfactory treatment for that insect is, for that reason, a possible key to the fireworm situation. If the fruit worm could be controlled without winter flooding, the forces of nature could be brought to bear in the fight with the fireworm by omitting flowage altogether.

The Cranberry Fruit Worm (*Mineola vaccinii* (Riley)).

Late holding of the winter flowage continues to be the only certainly reliable method of dealing at all satisfactorily with this insect. A better treatment is desired because the water does injury when held late every year. Any new treatment of value must probably be an indirect one.

As stated in last year's report (page 57), tests showed that the cocoons of the fruit worm are not impervious to water, for they were found to be wet inside when carefully opened after only a few minutes' submergence, the water apparently having penetrated them almost instantly. This was further tested later by wetting dry cocoons with a spray from a Vermorel nozzle, and the water seemed to strike through them as readily as it would have through a handkerchief. It seemed from this that it might be possible to kill the worms in their cocoons on the bog by spraying with some contact poison, as the spray would evidently soak through the cocoons at once. The writer conducted laboratory experiments with "Scalecide" and "Black Leaf 40" to determine what strength of

each it would take to kill the worms in this way. They were not killed when the cocoons were kept wet with a mixture of 1 part of "Scalecide" in 5 parts of water for a whole hour. As it would take not less than 600 or 700 gallons to wet down the surface of the sand on a bog, especially if the vines were at all thick, it became evident without further tests that "Scalecide" could not be used successfully in this way because of expense. It took a strength of 1 gallon of "Black Leaf 40" in 100 gallons of water to kill the worms when sprayed on the cocoons, and therefore treatment with this insecticide also seems too expensive to be practicable. However, further tests with other contact sprays are planned.

For dry bogs (without winter flowage) the possibilty of starving out this insect by destroying the bloom in seasons of light crop promise is still under consideration. Success in killing the blossom by spraying with a 20 per cent. solution of iron sulfate was reported last year. As it took three sprayings to destroy all the blossoms, however, it appeared that there might be danger in this method of treatment, as the application of so much iron sulfate might injure the vines. To determine this point, the sulfate salt was applied broadcast on two bog plots on June 17, this year, at the rate of 1 ton to the acre. A few of the vines showed a little injury afterward, but as far as the evidence obtained went, the sulfate may be used to kill the bloom without fear of its doing much damage. It is planned to test this matter further, however.

The study of the natural enemies of the fruit worm were continued, and many things of scientific importance were learned about its parasites. Some of this new information may in time lead to valuable practical results. In all, nearly a dozen species parasitic on this pest have been bred, but only three of them are abundant enough to be of much importance. These three species are: —

1. A Braconid (*Phanerotoma tibialis* Hald.), discussed in last year's report (pages 55 and 56). Cocoons containing worms parasitized by this species can usually be readily distinguished from those of normal, unparasitized worms by their much smaller size. When this parasite was reported on last year, it was assumed that it laid eggs in the eggs of the fruit worm when it parasitized them. This year's observations, however, seem to indicate that instead of laying eggs it injects living young into the fruit worm eggs, and is therefore viviparous. The writer failed to find the eggs of the parasite, but its larvæ can readily be found in fruit worm eggs even before the worms themselves have taken distinct form.

2. An Ichneumonid (*Pristomeridia agilis* (Cress.) Ashm., determined by R. A. Cushman of the United States national museum). This species was also mentioned in last year's report (page 56), but more knowledge concerning it has been obtained this year. It inserts its elongate, curved, black eggs into the body of the fruit worm, usually accomplishing this by sticking its egg-laying apparatus into the hole made in the berry by the worm. The eggs hatch within a few days after they are deposited in the tissues of the worm. This is a far less important parasite than the Braconid

(*Phanerotoma*), not only because it is much less abundant, but also because it usually deposits its eggs in worms which have already been parasitized by the Braconid. It is perhaps as much of a hindrance as a help because of this interference with the Braconid.

3. A Chalcidid (*Trichogramma minuta* Riley,[1] which is known to be parasitic on the eggs of forty-six other species of insects, the codling moth, the brown-tail moth, the pear-slug, the elm saw fly (American Cimbex), the fall web-worm, the corn ear-worm and the cotton worm being some of its important hosts). This, the most important parasite of the fruit worm, was a new find this year. It undergoes all its development and transformation in the fruit worm egg, causing the destruction of the egg, as far as the development of the worm is concerned, and emerging from it in July and August as a full-grown fly-like creature of such small size as to be hardly visible to the naked eye. Its presence in the eggs may be readily detected by their appearance, for they turn black when infested with it. Moreover, when the fruit worm itself hatches, the eggshell is left looking like a white flake, and the worm's place of emergence is not readily seen because of its location close to the surface of the berry. On the other hand, when the parasite has emerged the eggshell looks black and the emergence hole is conspicuous. The writer has noticed these black eggs several seasons, and, as he suspected parasitism in connection with them, he attempted to rear the parasites last year, but failed to do so, probably because the methods he employed were not suited to these very delicate creatures. This year, however, different methods were tried, and the adult parasites were obtained in considerable numbers without much trouble. This parasite destroyed about 56 per cent. of the fruit worm eggs on dry bogs near the station bog this year, about 700 eggs having been examined in making this estimate.

In last year's report (page 55), it was estimated that more than 50 per cent. of the fruit worms on a dry bog near the station bog had been parasitized in 1912. As nothing definite was then known about the Chalcidid egg parasite and its importance, that estimate was much too low, this year's investigations having shown that the natural enemies (parasitic and predacious) of the fruit worm took care of not less than 90 per cent. of the infestation on dry bogs, and of fully 66 per cent. on flowed ones, in the vicinity of the station during the season.

The writer's findings concerning the natural enemies of the flowed-bog fireworm and the bearing which flooding has on their effective activity have been discussed fully in previous reports, but they must be briefly brought to mind again here to show how they are supported by the results of this year's study of the distribution of the principal fruit worm parasites. The fireworm seriously damages only flowed bogs, and it becomes a pest because the flowage either drives out or destroys its natural enemies,

[1] Since this was written, this determination has been confirmed by Mr. A. A. Girault, the authority on the *Trichogrammatidæ*.

but does the insect itself no similar harm. A fireworm infestation always becomes noticeably injurious first at some distance from the upland, and bogs of large size and compact form are much more often badly infested than are smaller ones. This is due to the fact that it takes some time for the natural enemies of the pest to work in from the upland and become effectively numerous on all parts of a large bog, especially on the middle part, after the spring flooding is done. In connection with this fireworm situation, the following findings, concerning this year's distribution of fruit worm parasites on the station bog and on a dry bog near by, are distinctly interesting, the figures given in the table showing the percentage of fruit worm eggs or worms found parasitized in the different locations indicated: —

TABLE 6. — *Distribution of Effectiveness of Principal Fruit Worm Parasites.*

PARASITE.	Eggs or Worms of Fruit Worm examined.	Dry Bog.	Center of Station Bog.	Edge of Station Bog. (1)	Edge of Station Bog. (2)	Edge of Station Bog. (3)
Chalcidid, . .	Eggs, . .	56.0	14.0	28.0	44	–
Ichneumonid, . .	Worms, . .	26.4	4.6	10.4	10	10.6
Braconid, . . .	Worms, . .	47[1]	43[1]	–	–	–

[1] Because of a mathematical error by the writer, the percentages (32 and 30) given in the Report of the 27th Annual Meeting of the Cape Cod Cranberry Growers' Association, 1914, page 21, were incorrect.

It will be seen that the distribution of the Chalcidid and Ichneumonid parasitism was, in a general way, like that found to obtain, as shown in previous reports, with the enemies of the fireworm. The dry bog used in this comparison is about two acres in area. The center of the station bog is about 250 feet from the upland. The three "edge of station bog" locations were on different sides of the bog. The examinations on which these figures are based were made during the first two weeks in August. Each figure is an average, representing numerous examinations. The station bog was reflowed for the last time a little over seven weeks before these parasite investigations were made. When all these facts are considered, the great influence of flooding on the distribution of the first two of these parasites becomes at once apparent. It will be seen, however, that the water did not seem to affect the Braconid very much, the results of the investigation in this regard being contrary to those of last year's rearing tests. If last year's report is referred to (page 56), however, the following remark concerning the results of those tests will be found: "From a study of the life history of *Phanerotoma tibialis*, it is not easy to see just how the flowage can affect its prevalence to so marked an extent." In the present opinion of the writer it will be found that flooding does

affect the abundance of *Phanerotoma* considerably, though probably not to the extent indicated by the results of the 1913 investigations.

In studying the fruit worm parasitism, the writer has had the two following practical objects in view: —

1. *The Possibility of forecasting Seasons of Great Fruit Worm Injury.* — If relative abundance and scarcity of the parasites in different years has a strong bearing on the comparative abundance of the pest, we should probably be able to foretell with some degree of accuracy, after keeping records of the parasitism for several years, what is to be expected in this regard several months ahead.

2. *The Possibility of increasing the Natural Effectiveness of the Parasites by harboring them artificially in Some Way.* — Not enough has yet been learned about the Chalcidid parasite to make any definite plans in relation to it in this connection. The Braconid (*Phanerotoma*), however, can probably be handled without much difficulty, and experiments are already under way to determine whether its percentage of mortality is much greater under natural out-of-door "dry bog" conditions than it would be if its host worms were kept under the more even conditions of temperature and moisture which they would have in cold storage or in ordinary cellars. It is evident, of course, that on flowed bogs the majority of these Braconid parasites perish during the winter, and if the water is held late (until the latter part of May) they are probably almost exterminated. If, therefore, they can be wintered under artificial conditions without much loss, it ought to be possible to replenish the *Phanerotoma* parasitism on flowed bogs by gathering fruit worms every summer, allowing them to form their cocoons in captivity, wintering them in cold storage and returning the parasites to the bog when they emerge the following season. Of course many unparasitized worms would be wintered in this process, and as a result many moths would emerge with the parasites, but there is so much difference in size between the moths and parasites that they could be readily separated with a screen. After they were separated the moths, of course, would be destroyed.

Further submergence tests with fruit worms in their cocoons were begun on September 7, 15 different lots of a dozen each being submerged in water in long glass tubes 2 inches in diameter, at depths varying from 4 to 67 inches, on that date. All the worms used in these tests were collected from a bog, in their berries, between the 12th and 21st of August. They were submerged seventeen days, being removed from the water on September 24, and were all found to have been killed by the treatment. The tubes were kept in the station screen-house during these tests, and the water may have killed the worms because of its abnormal stagnation and high day temperature.

On October 19, further submergence tests were started, a part of the cocoons being put in water in tubes in the screen-house as before, while a part were submerged in light netting sacks suspended from a float in a pond. Some of these cocoons were removed from the water on Novem-

ber 4, after sixteen days of submergence, while others were kept submerged for twenty-five days, until November 13. On both dates it was found that all the worms which had been in the glass tubes were dead, while most of those taken from the pond were alive and capable of crawling actively soon after they were taken from their cocoons. The results of this test led to the suspicion that the worms in the tubes had died because of the extreme stagnation of the water, while those in the pond had perhaps been kept alive by air thrashed into the water by the wind.

A third lot of tests was started on November 12, two of the long glass tubes used in the previous tests being submerged in an upright position in a pond, netting sacks containing fruit worms in their cocoons being tied inside the tubes and also outside of them at different depths ranging from 9 to 61 inches. One tube was taken from the water on December 15 and the other on December 22. Of the 23 worms submerged with the former tube, the 6 outside ones were all lively, while 8 of the 17 inside were dead. Of the 21 worms submerged until the 22d, the 5 outside were all very much alive, while 3 of the 16 inside were dead. The tubes got dragged badly by the ice just before the first one was taken from the water, and most of the cocoon-containing sacks attached to the outside were torn from both, one being left with each. On the whole, the worms endured this prolonged submergence remarkably well. The stagnation of the water inside the tubes seemed to harm them somewhat.

From these and other submergence tests, it was learned that the fruit worm in its cocoon has great ability to resist drowning aside from any protection provided by the cocoon. The cocoons completely filled with water in about five days, so that the worms within them were entirely surrounded by it, there being no air bubble left to help keep them alive.

Water Movement in Peat.

As a part of the general study of cranberry bog drainage and irrigation, it seemed desirable to learn something about the rate of the passage of water through peat, as compared with its movement in other soils. For this purpose, on May 25, 12 holes 3 feet deep were dug 8 feet apart in the station bog, in a line running straight across a section 96 feet wide, those at each end of the line being located 4 feet from the ditch. Stakes were driven in these holes, and levels from which to measure the rise and fall of the water in each were carefully determined and marked upon them. In the latter part of May and in June and July observations and records were made, in connection with the vertical movement of the water in these holes, whenever the bog was being flooded or drained.

The record of May 29 is given here in full, it being fairly representative. In the morning, the ditches surrounding the section in which the holes were dug were comparatively empty, no standing water being visible in any except the large main ditch. The water level in one of the two middle holes (hole No. 7) was taken just before the bog pump was started at 9.30 A.M. and was found to be 97.16, as measured from a bench mark the

elevation of which was regarded as 100 feet. It was practically the same in hole No. 6. The pump was run for one and one-quarter hours, until 10.45 A.M., when holes Nos. 1 and 2 on one side of the section and Nos. 11 and 12 on the other side were full of water which had run over the surface of the sand into them. The water level in the ditches and these holes was then, as measured from the bench mark, 98.75. The surface water had not run into the other holes at all or come anywhere near them. At noon, one and one-quarter hours after the pumping was done, the water levels in the 12 holes and in the ditches were taken and found to be as follows: —

Ditch,	98.48	Hole No. 7,	98.07
Hole No. 1,	98.53	Hole No. 8,	98.10
Hole No. 2,	98.34	Hole No. 9,	98.17
Hole No. 3,	98.17	Hole No. 10,	98.09
Hole No. 4,	98.15	Hole No. 11,	98.30
Hole No. 5,	98.09	Hole No. 12,	98.37
Hole No. 6,	98.00		

This record shows a variation of only about 6⅓ inches in the water level two and one-half hours after the pumping was begun. Similar measurements were made again at 3.30 P.M., six hours after beginning pumping and four and three-quarters hours after stopping, and the variation was then found to be only about 1⅔ inches, the various levels being as follows: —

Ditch,	98.29	Hole No. 7,	98.21
Hole No. 1,	98.29	Hole No. 8,	98.21
Hole No. 2,	98.26	Hole No. 9,	98.26
Hole No. 3,	98.20	Hole No. 10,	98.21
Hole No. 4,	98.20	Hole No. 11,	98.26
Hole No. 5,	98.17	Hole No. 12,	98.26
Hole No. 6,	98.15		

The pump was started again at 4.20 P.M. (May 29) and run until 7 P.M. The planks were then put in, and all the water was held until 2 A.M. the following morning, at which time the water level on the bog was 99, all the 12 holes used in making the above measurements being entirely full. The water was allowed to run out of the bog freely from 2 A.M. until 10.45 A.M., when the levels in the ditches and in the holes were again taken and found to be as follows: —

Ditches,	97.48	Hole No. 7,	97.78
Hole No. 1,	97.57	Hole No. 8,	97.71
Hole No. 2,	97.71	Hole No. 9,	97.72
Hole No. 3,	97.71	Hole No. 10,	97.76
Hole No. 4,	97.73	Hole No. 11,	97.66
Hole No. 5,	97.71	Hole No. 12,	97.63
Hole No. 6,	97.79		

The elevation of the surface of the peat around these holes averaged roughly about 98.59. There was, therefore, a drainage in the peat of considerably over 9 inches in less than nine hours, at the middle of the section, at a distance of 44 feet from the nearest ditch. This shows that the horizontal movement of water through the peat of cranberry bogs is a very rapid one, if conditions at the station bog are representative.

Root Development.

A study of the seasonal development of the root growth of the cranberry was begun in a rough way and produced some interesting results. As stated in last year's report, Professor Coville, of the Bureau of Plant Industry of the United States Department of Agriculture, has found that the root development of blueberries, rather closely related to the cranberry, is very sluggish. This is also found to be true of the cranberry, though apparently not to so great an extent. On the fungous plots of the station bog this year there was practically no new root development until after the vines had bloomed, and most of the new growth came after blossoming time on the bog as a whole. The new roots were found, however, to start fairly early on bogs which are not winter flowed, some new growth being discovered on well-sanded portions of such bogs as early as May 7.

The winter flowage was let off from the station bog on May 5, and no new roots could be found on it on May 7. On May 26, a considerable growth of new rootlets had already taken place near the surface, but the lower roots showed no new development whatever. A season's root growth on cranberry bogs evidently begins, therefore, at the surface of the sand, where the roots have the most air and heat. In examinations made later in the season new roots were finally found deeper down in the bog, but the conditions that favored the starting of development near the surface evidently continued to have their influence more or less throughout the period of growth, causing the greater part of the season's root growth to be developed within two or three inches of the surface.

The degree of drainage does not seem to affect the new root development in the first part of the season (before the 1st of June), except that when the water table is so high (within three or four inches of the surface) that it makes the surface sand soppy the new rootlets are distinctly larger and more succulent than when they grow under dryer conditions.

Studies of the *Mycorhiza* fungi on cranberry roots were begun in a rough way, with the idea of first finding out, if possible, whether there is any great difference in the abundance of these fungi present in different sorts of bogs, attention being given particularly to comparisons between flowed and dry bogs, old bogs and new plantings, and vines growing on "hard bottom" and on "peat bottom." While this investigation has not advanced far enough to justify definite conclusions, it is apparent that different bog conditions have a considerable bearing on the abundance of these fungi.

Miscellaneous.

After most of the cranberry crop had been gathered, the fallen berries were picked up from under the vines on a large number of measured plots on the station bog and other bogs in the vicinity, to determine how much of the fruit was lost in different methods of harvesting. The loss ranged from an average of about 10 per cent. where the scoops were handled slowly and carefully to an extreme loss of over 25 per cent. where bogs with heavy crops were scooped hurriedly. The general conclusion arrived at from this investigation was that with low prices such as obtained this year, especially with the early berries, it is advisable to scoop rapidly on bogs with light or medium crops. Under the normal price conditions of previous years, however, it would pay, with heavy or medium crops, to pick slowly and carefully, prevention of waste being much more important than the keeping down of the labor expense of picking. It would sometimes pay, under such conditions, to spend as much as 80 cents a barrel on "Early Blacks" and $1 a barrel on "Late Howes" for careful scooping. Most of the berries dropped in scooping seem to be knocked off by the tips of the teeth of the scoop. For this reason, a scoop with teeth having rounded and flattened ends would probably lose less berries than one with pointed teeth.

This year of low prices has been generally discouraging to the cranberry growers. It will undoubtedly, however, benefit those interested in the industry to some extent by tending to curtail the planting of new bogs in the immediate future. Such prices may not prevail again for many years, for, as is generally realized, this year's conditions were very exceptional in many ways. If the time ever comes when very low prices are the rule year after year, the situation will not be hopeless, for, as in every other business, changes in methods will necessarily accompany changes in conditions. With low prices the rule, no attempt probably would be made by most growers to combat the various pests by methods now employed. The fruit worm, flowed-bog fireworm, tip worm and various other insects which occasionally become troublesome would be entirely controlled by holding the winter flowage very late (perhaps until nearly the 1st of July) every other year (or possibly every third year). Though the crop would be entirely lost in the year of late holding, its loss would be largely offset by the almost entire elimination of expense, and the crop of the following year, being free from the most commonly troublesome pests, and having behind it the strength of vines not weakened by the drain of a crop the year before, would give the best returns possible. The average quantity of berries produced yearly would perhaps not be as great as that obtained by present methods, but even with low prices the profits might not be seriously diminished, since a considerable reduction in expenses would be brought about by such management.

Cranberry growers frequently desire to know how high a temperature the water of June reflowage can have without doing serious damage to

the buds. The experience at the station bog in the last two seasons, therefore, should be both interesting and reassuring. Very hot weather occurred both years during the regular June reflow. The temperature of the water on the bog was taken with a Green thermometer, and the maximum reading obtained each year was 86° Fahr. In 1914, the reflow was continued for two days, the temperature of the water being 86° Fahr., at noon the first day and 81° the second. The withdrawal of the flowage was started at 2 A.M., the temperature of the water at that time being 71°. Higher temperatures probably will seldom be experienced in flooding. There was practically no damage to the buds.

Blueberries.

Owners of many "dry bogs" on the Cape will be interested to know of the work which has been done with blueberries in the New Jersey cranberry growing region. Prof. Frederick V. Coville of the United States Department of Agriculture and Miss Elizabeth C. White of New Lisbon, N. J., have co-operated in the selection and breeding of blueberries and have produced varieties with fruit of such superior size that the commercial growing of this fruit is soon to be taken up extensively by some of the New Jersey cranberry growers. There seems to be no reason why these blueberries should not do as well on Cape Cod as in New Jersey, and the peat soils used for growing cranberries are entirely suitable for them. Many dry bogs which are at present poor investments could, without doubt, be converted into blueberry plantations with great profit.

DEPARTMENT OF PLANT AND ANIMAL CHEMISTRY.

J. B. LINDSEY, *Chemist in Charge.*

THE EFFECT ON A CROP OF CLOVER OF LIMING THE SOIL.

BY F. W. MORSE.

This study of the effect of liming a soil on the composition of a crop of red clover has been made in the course of investigating soil-fertility problems connected with the oldest series of fertilizer plots at the Massachusetts Agricultural Experiment Station. The plots have been repeatedly described in the annual reports of the station, under experiments with nitrogenous fertilizers, and designated as "field A."

A brief description of the plots at this point will serve to make this particular study intelligible. The soil is a sandy loam, and the plots referred to in this paper have received only chemical fertilizers for a period of thirty-one years. No dung or litter has been applied, and organic matter has been supplied wholly by crops grown on the land in the form of roots and stubble, with an occasional catch crop plowed under.

Since 1890 the annual application of chemicals has been 45 pounds of nitrogen per acre in nitrate of soda or sulfate of ammonia; 80 pounds of phosphoric acid per acre in dissolved bone black, and 125 pounds of potash per acre in muriate of potash or the double sulfate of potash and magnesia.

Table I. shows the distribution of the different fertilizers among the plots.

TABLE I.

Plot 1. Nitrate of soda, dissolved bone black, muriate of potash.
Plot 2. Nitrate of soda, dissolved bone black, sulfates of potash-magnesia.
Plot 4. No nitrogen, dissolved bone black, sulfates of potash-magnesia.
Plot 5. Sulfate of ammonia, dissolved bone black, sulfates of potash-magnesia.
Plot 6. Sulfate of ammonia, dissolved bone black, muriate of potash.
Plot 7. No nitrogen, dissolved bone black, muriate of potash.
Plot 8. Sulfate of ammonia, dissolved bone black, muriate of potash.

The more recent history of cropping is as follows: in August, 1906, alsike clover was sown in the standing corn then occupying the field. The land remained unplowed for three years. The stand of clover was

poor, and each spring additional seed was sown on the surface, but grasses crowded into the bare spaces. In August, 1909, one-half of the field was limed at the rate of 3,000 pounds per acre with slaked lime, the application being made crosswise of the plots, so that every plot was half limed and half unlimed. Alsike clover was again sown, but as in preceding years the crop of 1910 consisted of more grass than clover.

In 1911 and 1912 corn was grown with good yields on all plots, and in the former year the product of the plots receiving no nitrogen, plot 4 and plot 7, was practically equal to that from plots 1 and 2, which received nitrate of soda. Attempts to get a stand of alsike clover were made in both years by sowing the seed in the standing corn late in July. Germination was good, but the clover was badly winterkilled both years.

The liming of one-half of the area in 1909 showed no appreciable results on either corn or clover. Therefore in 1913, when it was apparent that the land must again be plowed, another dressing of hydrated lime was applied at the rate of 4,000 pounds per acre.

Japanese millet was grown in 1913 with fair yields, but the crop was cut short by drought. The growth did not appear to be much influenced by the lime. In the spring of 1914 the plots were seeded with red clover, together with oats as a nurse crop. The oats were removed in July, and there were pronounced effects of the liming observable on all the plots, least on the plots receiving nitrate of soda.

After the oats were removed the clover on the limed halves of plots 4 and 7, receiving no nitrogen, was first to appear above the stubble. The clover on the whole area of plots 1 and 2, receiving nitrate of soda, and on the limed halves of plots 5, 6 and 8, receiving sulfate of ammonia, followed about one week later.

As the season progressed the clover on the limed areas receiving no nitrogen continued to lead all the other plots in size and vigor of growth, and began to bloom several days ahead of them. The whole area receiving nitrate of soda looked uniform to the eye, but a little behind the limed area without any nitrogen. The limed areas receiving sulfate of ammonia were like the areas receiving nitrate of soda. The unlimed areas without nitrogen produced a slow-growing crop which looked scanty in comparison with the growth on the limed portions of the same plots, but an examination of the ground showed the plants to be as numerous on one area as on the other. The clover on the unlimed areas receiving sulfate of ammonia looked noticeably inferior to all other plots without lime, and the division between the limed and unlimed halves of the plots was clearly marked by vigorous, thrifty plants on the limed areas and small stunted ones on the unlimed. A similar line of demarkation existed on the plots receiving no nitrogen, but was barely, if at all, noticeable on the plots receiving nitrate of soda.

The pronounced effect of liming the soil on the growth of clover made it seem possible that a chemical investigation would show some specific effect of the lime on the composition of the plants. Accordingly, samples

of clover plants were gathered from both limed and unlimed areas of the plots mentioned in Table I. and samples of clover roots from both halves of plots 2, 5 and 7.

The samples of clover were obtained on Sept. 14 and 15, 1914, when the crops on the limed halves of plots 4 and 7, without nitrogen, were in full bloom, and on the other limed areas were partly so. The unlimed halves of plots 1 and 2, dressed with nitrate of soda, appeared to be as much in bloom as the limed halves, but the remaining unlimed areas showed no flowers nor buds. The samples were gathered by cutting the plants near the ground with grass shears, and each half of a plot was represented by a large number of plants which were taken from all sections of it. The unlimed areas of plots 4, 5, 6, 7 and 8 were most thoroughly represented because the growth on them was so much smaller that many more plants were needed to make samples of sufficient size.

The samples of clover roots were obtained by digging representative plants with a spade, taking up a block of soil about 8 inches in depth. The blocks of soil were exposed to the action of water from a hose-nozzle, care being taken that the rootlets were not broken as the soil was washed away. The process was slow, and it required the time from September 16 to 19, inclusive, to prepare the samples desired. The samples were, however, obtained under uniform conditions, as the weather was fair throughout the sampling. After the roots were washed free of earth they were cut from the plants and dried.

The roots from both halves of plot 2, dressed with nitrate of soda, were large and thrifty and bore numerous nodules. The roots from the limed halves of plots 5 and 7 were apparently similar in all respects to those from plot 2. On the other hand, the roots from the unlimed half of plot 5, dressed with sulfate of ammonia, were much smaller than those from the limed half, and nodules were few and very small. The roots from the unlimed half of plot 7, receiving no nitrogen, were thriftier than those just described, but were not so thrifty in appearance as those on the limed half and bore smaller nodules.

All samples were dried at a temperature around 75° C. until sufficiently brittle to be easily pulverized. They were then ground to a powder, after which moisture was determined in order that all subsequent analytical work could be based on the dry matter. No attempt was made to determine the percentage of dry matter as it was not essential.

The tentative plan for chemical analysis included total nitrogen as the most easily determined organic constituent, total ash as a guide to the mineral constituents, iron oxide and calcium oxide. Iron oxide seemed important because in our soil-fertility investigations Mr. Ruprecht has found soluble iron salts in the unlimed areas of some of the plots,[1] and has studied their effects on the growth of clover.[2] The percentage of calcium oxide in the clover was expected to be modified by the application

[1] Investigations not yet published.

[2] See second part of this bulletin.

of lime to the soil, and it was also thought that the iron oxide would be modified somewhat by it. The results of the analytical work are given in Table II.

Table II. — *Composition of Clover (Dry Matter) (Per Cent.).*

		Plot 1.	Plot 2.	Plot 4.	Plot 5.	Plot 6.	Plot 7.	Plot 8.
Ash,	Limed,	11.04	10.79	10.39	10.64	10.35	10.85	10.92
	Unlimed,	10.99	10.31	10.82	10.68	10.51	11.16	11.40
Ferric oxide,	Limed,	.11	.14	.06	.15	.11	.12	.09
	Unlimed,	.13	.13	.09	.20	.09	.16	.12
Calcium oxide,	Limed,	2.04	1.80	1.63	1.85	1.99	1.90	2.01
	Unlimed,	2.21	1.96	1.95	2.05	2.46	2.43	2.51
Nitrogen,	Limed,	3.71	3.60	3.53	3.57	3.66	3.39	3.73
	Unlimed,	3.49	3.28	3.06	2.74	2.64	2.80	2.88

Composition of Clover Roots (Dry Matter) (Per Cent.).

		Plot 2.	Plot 5.	Plot 7.
Ash,	Limed,	7.25	6.79	6.26
	Unlimed,	7.31	7.93	7.12
Ferric oxide,	Limed,	.40	.40	.24
	Unlimed,	.47	.61	.36
Calcium oxide,	Limed,	.59	.53	.60
	Unlimed,	.48	.41	.54
Nitrogen,	Limed,	2.77	2.77	2.45
	Unlimed,	2.43	1.76	1.88

The composition of the samples of clover from the limed areas proved to be more uniform than the composition of samples from the unlimed, the range of percentages between maxima and minima being narrower in the constituents of the former series. The mineral constituents are slightly higher in the clover from the unlimed areas, and this is most positively defined in the percentages of calcium oxide. On the other hand, the nitrogen is markedly lower in the unlimed group of samples.

The composition of the roots differed somewhat from that of the tops. The constituents determined, except iron oxide, were much lower in percentage than those in the tops. The percentages of nitrogen varied in the same manner as in the tops, while calcium oxide was higher in the roots from limed areas, and the iron oxide was higher in those from unlimed areas.

Variations in the percentages of ash in the roots were probably due in part to the presence of clay, which could not be completely washed from the roots. This was clearly indicated by the following experiment. Parallel ash determinations were made on the roots from the unlimed half of plot 5 and those from the limed half of plot 7, which represented, respectively, the maximum and minimum ash percentages. After weighing the total ash it was dissolved in strong hydrochloric acid, then diluted with water and filtered. The insoluble residue on the filter was then ignited and weighed. The soluble ash percentages were nearly alike.

	Plot 5, Unlimed (Per Cent.).	Plot 7, Limed (Per Cent.).
Total ash,	7.45	6.24
Insoluble residue,	2.24	1.20
Soluble ash,	5.21	5.04

The percentages of ash, iron oxide and calcium oxide throw no light on the specific effect of liming the soil. There appears to be neither too much iron nor too little calcium in the tissues of the plants from the unlimed areas, unless the small differences in the percentages from limed and unlimed roots are sufficient to warrant such a deduction.

The marked differences in the nitrogen percentages in the unlimed crops when compared with those in the limed crops justify the deduction that available nitrogen was an important factor in promoting the growth of the plants. It is well known that carbonate of lime is beneficial to bacterial development; therefore it is reasonable to conclude that fixation and nitrification of nitrogen have been accelerated on the limed areas to the marked advantage of the plants, in comparison with those on the unlimed areas.

The increased formation of available nitrogen can be considered as true even for the plots receiving nitrate of soda, because 45 pounds of nitrogen would be completely used in 1,233 pounds of dry matter containing an average of 3.65 per cent. of nitrogen, which is the average for the crops from the limed halves of plots 1 and 2. That amount of dry matter represents a small yield of clover hay per acre, to say nothing of the roots of the crop, which contained 2.77 per cent. of nitrogen. In this instance the clover was not harvested, and we have no weights to confirm our opinion.

Besides the lessened availability of the nitrogen on the unlimed halves of the plots dressed with sulfate of ammonia there was also the probable hindrance to root development due to the presence of sulfate of iron and sulfate of aluminum, noted by Mr. Ruprecht in his work on the soils from these plots. As already noted in the description of samples, the roots obtained from the unlimed half of plot 5 were much smaller than

those from the limed half, although they did not show the thickened, dwarfed forms obtained in some of the water cultures.

The results of this work point to an effect of the lime on the soil constituents, by which the root environment is improved, rather than to an effect within the plant by the absorption of a larger amount of calcium salts.

TOXIC EFFECT OF IRON AND ALUMINUM SALTS ON CLOVER SEEDLINGS.

BY R. W. RUPRECHT.

During the study of the soil from field A it was found that marked amounts of soluble aluminum and iron salts were removed from the plots receiving sulfate of ammonia by long-continued washing of the soils with distilled water, while no aluminum and only traces of iron were removed from the plots receiving nitrate of soda. This led to the conclusion that the iron and aluminum salts might be the causes of the poor crops, and water-culture work, using these salts, was undertaken.

At the time these culture experiments were started practically no work of this nature, using iron and aluminum salts in water cultures, had been reported. Since then, however, Connors of Indiana has published[1] results of the toxic action of aluminum on corn seedlings, and Gile has published[2] results of the toxic effect of salts of iron on rice seedlings.

The salts used by me were ferrous sulfate and aluminum ammonium sulfate. The alum was used instead of aluminum sulfate because the latter was not on hand.

Standard solutions of the above salts of one-tenth molecular strength were made up, and different amounts were added to the nutrient solution.

The nutrient solution used was a slight modification of Pfeffers, and was made up as follows: —

Solution (*a*): 20.5 grams $MgSO_4$ dissolved in 350 c.c. distilled water.
Solution (*b*): 40 grams $Ca(NO_3)_2$, 10 grams KNO_3, 20.56 grams Na_2HPO_4 dissolved in 350 c.c. distilled water.

One hundred cubic centimeters of solution (*a*) and 100 cubic centimeters of solution (*b*) were then added to 9.8 liters of distilled water, and a few drops of ferric chloride solution added.

The seeds were germinated on paraffin-coated wire gauze as described in Bulletin No. 70, Bureau of Soils. When the stems of the seedlings reached a length of 1 inch they were transferred to notched corks and placed in the culture solutions.

The culture solutions were contained in salt-mouth bottles of 250 cubic centimeters capacity, with necks having a diameter of 1¼ inches.

[1] Indiana Experiment Station Bul. No. 170.
[2] Jour. of Agricultural Research, Vol. III., No. 3.

Four seedlings were placed in each bottle. As each experiment was carried on in triplicate this gave a total of twelve seedlings for each treatment.

The first experiment was carried on with aluminum salt and red clover seedlings.

Treatment employed in First Experiment.

1. Nutrient solution (check).
2. Nutrient solution+10 c.c. 1/10 molecular solution of ammonia alum =216 parts per million of Al.
3. Nutrient solution+5 c.c. 1/10 molecular solution of ammonia alum =108 parts per million of Al.
4. Nutrient solution+2 c.c. 1/10 molecular solution of ammonia alum =43 parts per million of Al.
5. Same as No. 2+CaO
6. Same as No. 3+CaO
7. Same as No. 4+CaO

(Nos. 5–7:) approximately .5 gram of CaO was added to each bottle.

At the end of the first week quite marked differences were noticed in the roots, while the tops of all but the check were about alike. The roots of all but the check and No. 7 (43 p. p. m. Al + CaO) were very much stunted. The roots consisted of the single taproot without root hairs. Four days later the tops began showing differences similar to the roots. The worst seedlings were those in the highest concentration of aluminum, the conditions improving with a decrease in the amount of aluminum present. The presence of the calcium oxide seemed to counteract the toxic effect in a marked degree but not entirely, except in the most dilute solution. At the end of four weeks, when the experiment was discontinued, the differences were the same as noted at the end of the first week, only more pronounced. The seedlings in the bottles containing 216 parts per million (No. 2) and 108 parts per million (No. 3) of the aluminum, respectively, had died at the end of the third week, even in those treated with calcium oxide. The check was in excellent condition and No. 7 (43 p. p. m. + CaO) was fair.

In the second experiment a series of cultures with ferrous sulfate was added, and instead of using calcium oxide to neutralize the toxic action of the aluminum salt the carbonate and sulfate were used in order to avoid the danger of having the nutrient solution become alkaline from the calcium oxide. Enough of the carbonate and sulfate was added to make a saturated solution.

Treatment employed in Second Experiment.

1. Nutrient solution
2. Nutrient solution+$CaCO_3$
3. Nutrient solution+$CaSO_4$

(Nos. 1–3:) checks.

4. Nutrient solution+2 c.c. 1/10 molecular aluminum sol. =43 p.p.m. of Al.
5. Nutrient solution+2 c.c. 1/10 molecular Al sol.+$CaCO_3$.
6. Nutrient solution+2 c.c. 1/10 molecular Al sol.+$CaSO_4$.
7. Nutrient solution+1 c.c. 1/10 molecular Al sol. =21.6 p.p.m. of Al.
8. Nutrient solution+1 c.c. 1/10 molecular Al sol.+$CaCO_3$.

9. Nutrient solution+1 c.c. 1/10 molecular Al sol.+$CaSO_4$.
10. Nutrient solution+10 c.c. 1/10 molecular sol. $FeSO_4$=22 p.p.m. of Fe.
11. Nutrient solution+10 c.c. 1/10 molecular $FeSO_4$ sol.+$CaCO_3$.
12. Nutrient solution+10 c.c. 1/10 molecular $FeSO_4$ sol.+$CaSO_4$.
13. Nutrient solution+5 c.c. 1/10 molecular $FeSO_4$ sol. =11 p.p.m. of Fe.
14. Nutrient solution+5 c.c. 1/10 molecular $FeSO_4$ sol.+$CaCO_3$.
15. Nutrient solution+5 c.c. 1/10 molecular $FeSO_4$ sol.+$CaSO_4$.
16. Nutrient solution+2 c.c. 1/10 molecular $FeSO_4$ sol. =4.5 p.p.m. of Fe.
17. Nutrient solution+2 c.c. 1/10 molecular $FeSO_4$ sol.+$CaCO_3$.
18. Nutrient solution+2 c.c. 1/10 molecular $FeSO_4$ sol.+$CaSO_4$.

At the end of three days most of the plants in the higher concentrations of the ferrous sulfate had died. These were replaced, but by the end of the first week these too had died. This failure of the plants to make a start was, I think, in part due to unfavorable weather, there being practically no sunshine during this first week. The same differences as indicated in the first experiment were noticed in this series. Calcium carbonate counteracted the toxic influence of the aluminum salt in both concentrations to a marked degree, but not entirely. In the iron-treated solutions the calcium carbonate had a slightly beneficial effect on No. 14 (11 p. p. m. of Fe), more beneficial on No. 17 (4.5 p. p. m. of Fe), but no effect on the highest concentration (22 p. p. m. of Fe). Calcium sulfate had no effect, the plants being similar to those in the solutions of the same concentrations without the calcium salt. It was also noticed that the seedlings in the solutions containing the iron and aluminum salts without the addition of calcium had a tendency to have stems of a reddish color. The experiment was discontinued at the end of the third week, as most of the plants had died from excessive heat. An extremely hot spell made it impossible to keep the greenhouse cool.

The third experiment was a repetition of the second, with the exception that the highest concentration of the ferrous salt was omitted, and a more dilute one added.

Treatment employed in Third Experiment.

1. Nutrient solution
2. Nutrient solution+$CaCO_3$ } checks.
3. Nutrient solution+$CaSO_4$
4. Nutrient solution+2 c.c. 1/10 molecular aluminum sol. =43 p.p.m. of Al.
5. Nutrient solution+2 c.c. 1/10 molecular aluminum sol.+$CaCO_3$.
6. Nutrient solution+2 c.c. 1/10 molecular aluminum sol.+$CaSO_4$.
7. Nutrient solution+1 c.c. 1/10 molecular aluminum sol. =21.6 p.p.m. of Al.
8. Nutrient solution+1 c.c. 1/10 molecular aluminum sol.+$CaCO_3$.
9. Nutrient solution+1 c.c. 1/10 molecular aluminum sol.+$CaSO_4$.
10. Nutrient solution+5 c.c. 1/10 molecular $FeSO_4$ sol. =11 p.p.m. of Fe.
11. Nutrient solution+5 c.c. 1/10 molecular $FeSO_4$ sol.+$CaCO_3$.
12. Nutrient solution+5 c.c. 1/10 molecular $FeSO_4$ sol.+$CaSO_4$.
13. Nutrient solution+2 c.c. 1/10 molecular $FeSO_4$ sol. =4.4. p.p.m. of Fe.
14. Nutrient solution+2 c.c. 1/10 molecular $FeSO_4$ sol.+$CaCO_3$.
15. Nutrient solution+2 c.c. 1/10 molecular $FeSO_4$ sol.+$CaSO_4$.
16. Nutrient solution+1 c.c. 1/10 molecular $FeSO_4$ sol. =2.2. p.p.m. of Fe.
17. Nutrient solution+1 c.c. 1/10 molecular $FeSO_4$ sol.+$CaCO_3$.
18. Nutrient solution+1 c.c. 1/10 molecular $FeSO_4$ sol.+$CaSO_4$.

As in the previous experiments the roots showed marked differences at the end of the fourth day, while the tops showed no differences until a week had elapsed. The roots of the aluminum and iron treated bottles were very much stunted, and either consisted of only one main taproot without laterals or root hairs, or else quite a number of short thick roots growing from the base of the stem. The laterals only grew about a sixteenth of an inch and then stopped. All of the stunted roots were thicker than the unaffected ones, and despite their much smaller number and shorter length weighed as much as the healthy roots. At the end of six weeks the experiment was discontinued and photographed (Plates I. and II.). The seedlings in the 2.2 parts per million iron solution (No. 16) were almost normal, and where calcium carbonate had been added (No. 17) showed practically no differences from the check. The seedlings in the 4.4 parts per million iron solution (No. 13) made little growth after the first week, but did not die, and where calcium carbonate was added the toxic action was in part overcome. In the 11 parts per million iron solution (No. 10) the plants died at the end of the fourth week. Calcium carbonate in this case seemingly had no effect. As was already noted in the second experiment calcium sulfate had no effect in counteracting the toxic action of the salts. The results with the aluminum salt were exactly similar to those of the first and second experiment.

Summarizing the results of the three experiments we find as follows: —

1. That aluminum sulfate, when present in culture solutions in concentrations greater than 40 parts per million of aluminum, has a very toxic action on clover seedlings.

2. That ferrous sulfate when present in culture solutions in concentrations above 4 parts per million of iron exerts a toxic effect on clover seedlings.

3. That this toxic effect of iron and aluminum can, in a large measure, be overcome by the use of calcium carbonate up to a certain point, beyond which it has no effect. Calcium sulfate does not have this beneficial effect. This would seem to indicate that it was not the presence of calcium alone to which the antitoxic action was due, but rather to the combination in which it is present. Calcium in the form of the carbonate precipitates the iron and aluminum in the form of hydroxides, and thus removes them from solution and counteracts their harmful action. The toxic action of the higher concentrations of iron and aluminum, despite the excess of calcium carbonate present, is due, I think, to the solubility of the iron hydroxide. The aluminum hydroxide being less soluble, the toxic effect, even in the most concentrated solutions, is almost entirely counteracted by the calcium carbonate.

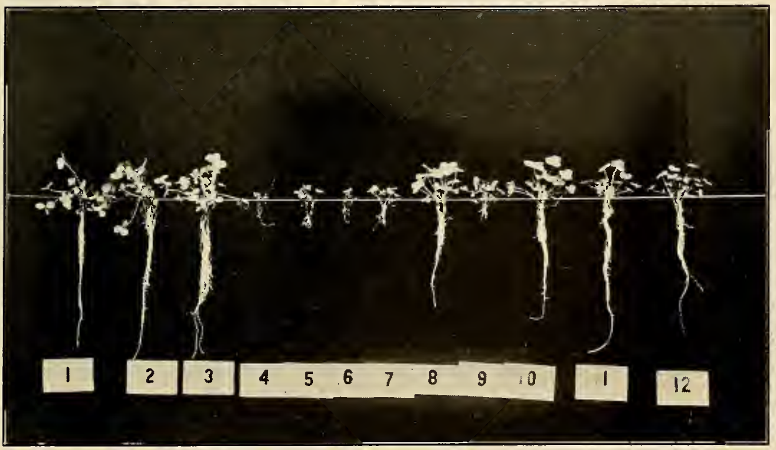
4. The idea that the toxicity of iron and aluminum salts is due to the penetration of the salts into the seedlings does not seem to be borne out. That the toxic action seems to be entirely in the first layer or two of cells in the growing portion of the roots is borne out by the following: a microscopical examination[1] shows that the stunting of the roots is due

[1] Made by Mr. G. H. Chapman.

PLATE I.

No. 1, Nutrient sol.; No. 2, Nutrient sol.+$CaCO_3$; No. 3, Nutrient sol.+$CaSO_4$; No. 4, Nutrient sol.+2 c.c. Al sol.; No. 5, same as No. 4+$CaCO_3$; No. 6, same as No. 4+$CaSO_4$; No. 7, Nutrient sol.+1 c.c. Al sol.; No. 8, same as No. 7+$CaCO_3$; No. 9, same as No. 7+$CaSO_4$

PLATE II.



No. 1, Nutrient sol.; No. 2, Nutrient sol.+$CaCO_3$; No. 3, Nutrient sol.+$CaSO_4$; No. 4, Nutrient sol.+5 c.c. Fe sol.; No. 5, same as No. 4+$CaCO_3$; No. 6, same as No. 4+$CaSO_4$; No. 7, Nutrient sol.+2 c.c. Fe sol.; No. 8, same as No. 7+$CaCo_3$; No. 9, same as No. 7+$CaSO_4$; No. 10, Nutrient sol.+1 c.c. Fe sol.; No. 11, same as No. 10+$CaCO_3$; No. 12, same as No. 10+$CaSO_4$.

to the arresting of the development or killing of the cells in the growing portion of the root, and not to a poisoning of the entire root system. This is further shown by the large number of short roots which develop from the base of the stem and grow until they touch the toxic solution. The continued growth of the tops after the roots have become stunted also seems to point to the fact that the injury was confined to the growing tips of the roots. If internal, the tops would show the effects sooner than from four to six days after the effect is noticed on the roots. The reason the seedlings finally die is due to a lack of nourishment rather than to a poisoning of the seedling itself. Finally, as Mr. Morse has shown in the preceding article, no appreciable increase in the amount of iron is found in the roots or tops of clover plants whose poor growth in comparison with normal clover plants is assumed to be due to the toxic action of iron.

PHOSPHATES IN MASSACHUSETTS AGRICULTURE; IMPORTANCE, SELECTION AND USE.

WM. P. BROOKS.

SUMMARY.

A. In some of the corn-belt States farmers are advised that phosphorus is the key to permanent and profitable agriculture, and that fine-ground rock phosphates should be used to supply that element.

B. It is pointed out in support of this position that in the agriculture of that section the soils contain relatively little phosphorus and are being rapidly depleted in that element; that they contain practically exhaustless stores of potash; and that by suitable use of lime and the growth of legumes their need for nitrogen can be met.

C. It will be the purpose of this bulletin to show to what extent these statements apply under Massachusetts conditions.

D. It is believed that the facts and results presented will justify the following conclusions: —

1. Massachusetts soils, though not usually supplying as much phosphoric acid as maximum crops require, show a much less signal relative deficiency in that element than corn-belt soils.

2. In our system of agriculture our soils are not being depleted in phosphoric acid, some of the more important reasons being: —

(*a*) The products sold carry relatively little phosphoric acid.

(*b*) Purchased grain and by-products, fed largely on our farms, contain large amounts of phosphoric acid which finds its way to our soils in farm manures, since phosphoric acid, voided in the dung, does not waste appreciably between the stable and the field.

(*c*) The practice of supplementing manures with commercial fertilizers, except where the former as in some types of market gardening are applied in enormous quantities, has been for many years and is now practically universal, and as a rule these commercial fertilizers contain a high proportion of phosphoric acid.

(*d*) Phosphoric acid, even when applied in soluble forms, is fixed and retained in the soil under ordinary soil conditions. This compound is subject to little or no loss by leaching.

3. Experiments in this station and elsewhere in the State indicate that for most of our leading crops potash far more frequently than phosphoric acid is the dominant food requirement. The only prominent exceptions are the crucifers, — cabbage, turnip, etc.

4. Notwithstanding the fact that potash is usually the more important of the two the use of phosphoric acid in our agriculture is generally profitable, as will be shown by the results of experiments presented.

5. It will be shown that when both dissolved and fine-ground natural rock phosphates are annually applied the former have given both the larger and the more profitable crop increases over a long series of years.

6. It will be shown that although more than 1,600 pounds per acre of phosphoric acid in the form of natural rock phosphates have been applied in a series of experiments extending over eighteen years, the yields on these plots at present are even more inferior to the yields on plots receiving the same amount of phosphoric acid in the more soluble phosphates than in the earlier years of the experiments.

7. It will be shown that the dissolved phosphates have exerted certain highly important secondary effects, among the more important being: —

(*a*) Stimulation to rapid early growth both of root and top, which secures, among other important advantages, sufficient root growth to more surely draw from the soil from the start both the water and the food needed, and ability better to resist insect injuries.

(*b*) Earlier and more perfect maturity, which may mean a much higher price for the product, as in market gardening, or immunity from frost damage in the case of late ripening crops or cold summers.

(*c*) It will be pointed out that the work of others appears to demonstrate the following additional secondary effects following the judicious use of dissolved phosphates: increased tillering of grain and grasses; increased availability of some important soil constituents; greater activity of nitrifying organisms in the soil; and larger soil gain in atmospheric nitrogen as a result of increase in assimilation of this element by micro-organisms in the soil.

8. Results will be presented which indicate that reasonable use of an acid phosphate does not increase the necessity for application of lime, — indeed, that in the experiments cited it appears to have had the opposite effect.

9. The final conclusions drawn from a consideration of all the facts and results discussed may be thus stated: —

(*a*) In Massachusetts agriculture it usually pays to use phosphoric acid containing fertilizers in at least moderate amounts.

(*b*) The more soluble phosphates are better adapted to our needs than the fine-ground natural rock phosphates. Among materials ordinarily used for supplying phosphoric acid only, usually most available and satisfactory, are acid phosphate, dissolved bone black and basic slag meal. Almost all mixed and special complete fertilizers contain liberal amounts of soluble and available phosphoric acid. Other sources of phosphoric acid in soluble or fairly available forms are dissolved bone, bone meals, tankage and fish, all of them also supplying some nitrogen.

INTRODUCTION.

During the last few years the system in the use of fertilizers, and more particularly the practice of depending upon fine-ground rock phosphate, so strongly advocated by Dr. Cyril G. Hopkins and some others, and based largely upon experimental results obtained by Dr. Hopkins in Illinois, have been prominently advocated in some of our agricultural papers for adoption under Massachusetts conditions. At the present time a company interested in the sale of fine-ground natural phosphate is carrying on an active propaganda which aims to convince our farmers, fruit-growers and gardeners that the chief fertilizer requirement of their soils is phosphoric acid, and that fine-ground natural rock phosphate is the material best adapted to their needs. The literature sent out by this company is being distributed everywhere. The conclusions urged are supported by numerous quotations, figures and illustrations drawn chiefly from the publications of experiment stations in the great central valley — the corn-belt — of the United States. This matter is so marshalled and presented that the argument seems likely to produce a strong impression; it may carry conviction to many minds.

It is of the utmost importance to our agriculture that the extent to which the teachings of Dr. Hopkins (the father of the system) are applicable under Massachusetts conditions should be known. If he be right, then certainly our farmers are buying unnecessary fertilizer elements, and needlessly paying the fertilizer manufacturers to render the phosphoric acid of the rock phosphates soluble and available. The adoption here of the Hopkins system, if sound, must mean a more profitable agriculture.

It seems, therefore, highly important that the whole question should be most carefully studied. Local conditions must be compared with corn-belt conditions; the results of local experiments must be presented and studied. It is well known that practice must usually vary with locality. A practice wise in one section is often most unwise in another where conditions are different.

The general features of the Hopkins system are stated on page 159 of his book on "Soil Fertility and Permanent Agriculture," from which the following quotation is taken: —

> For practically all of the normal soils of the United States, and especially for those of the Central states, there are only three constituents that must be supplied in order to adopt systems of farming that, if continued, will increase, or at least permanently maintain, the productive power of the soil. These are *limestone*, *phosphorus* and *organic matter*. The limestone must be used to correct acidity where it now exists or where it may develop. The phosphorus is needed solely for its plant-food value. The supply of organic matter must be renewed to provide nitrogen from its decomposition and to make available the potassium and other essential elements contained in the soil in abundance, as well as to liberate phosphorus from the raw mineral phosphate naturally contained in or applied to the soil.

The value of an application of lime in some form to many of our soils is fully recognized. It is frequently an essential for successful crop production. The importance of organic matter is admitted. It is useful not alone in promoting the availability of such elements as potassium and phosphoric acid, and as a source of nitrogen to the growing crop, but also for the maintenance of satisfactory soil texture. Without a fair proportion of such matter in the soil good tilth is impossible, and on the lighter soils, especially, extreme injury to crops in periods of drouth is a certainty. These phases of the general subject of fertility will not be discussed in this paper. It is proposed simply to study the question of the applicability of the Hopkins theory in relation to the use of phosphorus [1] to Massachusetts conditions.

The quotation above cited makes it apparent that Hopkins regards the application of fertilizer nitrogen or potash under normal soil conditions as superfluous, and that he believes that a suitable application of phosphorus (in addition to lime and organic matter) is all that will be found needful.

The conclusions of Dr. Hopkins are further emphasized and the reasons therefor more clearly brought out by the following quotation from the book above referred to: [2] —

Phosphorus is the only element that must be purchased and returned to the most common soils of the United States. *Phosphorus is the key to permanent agriculture on these lands.* To maintain or increase the amount of phosphorus in the soil makes possible the growth of clover (or other legumes) and the consequent addition of nitrogen from the inexhaustible supply in the air; and, with the addition of decaying organic matter in the residues of clover and other crops and in manure made in large part from clover hay and pasture and from the larger crops of corn and other grains which clover helps to produce, comes the possibility of liberating from the immense supplies in the soil sufficient potassium, [3] magnesium, and other essential abundant elements, supplemented by the amounts returned in manure and crop residues, for the production of large crops at least for thousands of years; whereas, if the supply of phosphorus in the soil is steadily decreased in the future, in accordance with the past and present most common farm practice, then poverty is the only future for the people who till the common agricultural lands of the United States.

And this does not refer to the far-distant future only, for the turning point is already past on most farms in our older states and on many farms in the corn belt; and lands that have passed their prime with sixty years of cultivation will decrease rapidly in productive power and value during another sixty years of similar exhaustive farm practice.

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[1] Phosphorus is the element of value as plant food supplied by the compound phosphoric acid, which is the most valuable constituent of acid phosphate, dissolved bone black, basic slag meal, fine-ground rock phosphates and raw and steamed bones. In the publications of this experiment station and in agricultural literature in general the name "phosphoric acid" is usually used. Figures indicating the amounts of phosphoric acid can be converted into approximate equivalents in phosphorus by multiplying by .44; and figures for phosphorus into substantial equivalents in phosphoric acid by multiplying by 2.3.

[2] Hopkins' "Soil Fertility and Permanent Agriculture," page 183.

[3] Potassium is the name of the element of plant-food value in the compound potash or potassium oxid, under which names in our station publications and in agricultural literature in general this plant food is usually referred to. Figures for potash (or potassium oxid) can be converted into approximate equivalents in potassium by multiplying by .83; figures for potassium can be converted into potash (or potassium oxid) by multiplying by 1.2.

Some of the more essential among the reasons which Dr. Hopkins here advances in support of his system of dependence upon application of fine-ground rock phosphate are the following: —

1. Phosphorus is already dangerously deficient in the soils of our older States, and is rapidly becoming more so.

2. There are, on the other hand, in the most common soils of the United States, "immense supplies of potassium" (and other essential elements), — enough, "supplemented by the amounts returned in manures and crop residues," for the production of "large crops at least for thousands of years."

3. If limestone be first applied to neutralize existing acidity, and fine-ground rock phosphate thereafter abundantly applied, the soil will become fitted for the growth of clover (or other legumes).

4. The growth of clover makes possible the acquisition of nitrogen from the air, so that this element need not be purchased.

5. If organic matter in the residues of clover and other crops, and in manure made largely from clover hay and pasture, be abundant in the soil, the phosphoric acid of the natural rock phosphates will be rendered available with sufficient rapidity for large crop production.

6. The use of rock phosphate instead of acid phosphate or (by fair implication I think) other sources of phosphoric acid means a large saving in money outlay.

7. The results of numerous experiments which it is held prove the soundness of these conclusions are presented in the book above referred to, in bulletins of the Illinois Experiment Station, as well as in other writings by Dr. Hopkins, who in the book and to some extent elsewhere also quotes results obtained in several other experiment stations.

It is proposed to consider these propositions, as to the degree of their applicability to the conditions of our agriculture, in the light of such experimental work bearing upon them as has been done in this experiment station. The writer would call particular attention to the fact that this study is not entered upon because of any doubt of the validity and soundness of Dr. Hopkins's conclusions and advice in so far as they relate to the conditions of the corn-belt. He is at the same time an able investigator and a tireless worker. His work has been of enormous value to the farmers of the corn-belt.

Among the reasons enumerated the first and second, both of which relate to the composition of the soil, are most conveniently considered together.

RELATION OF MASSACHUSETTS AGRICULTURE TO SOIL COMPOSITION, AND RESULTS OF CHEMICAL ANALYSES.

Under the system of agriculture most common in the corn-belt States phosphoric acid is largely carried away from the farm in products sold. Wheat, corn, oats, beef, mutton, pork and milk are all rich in this compound. In view of this fact it is not surprising that, as Dr. Hopkins points

out, the supply of phosphorus in the soils has decreased steadily under the system of agriculture pursued, and is now steadily decreasing under the most common farm practice.

Conditions in Massachusetts are widely different: —

1. The principal products sold from our farms are hay, vegetables, fruit and milk. The latter is the only product which carries away much phosphoric acid, and the proportion in this is small. The milk of 20 cows for one year (6,000 pounds each) will contain only about 100 pounds of phosphorus.

Timothy hay contains over four times as much potash as phosphoric acid; medium red clover, five times; cabbages, four times; potatoes, six times; and other vegetables in about the same proportion. In fruits the amount of potash is about six times the amount of phosphoric acid. If we reduce these figures to the basis of phosphorus and potassium used by Hopkins the comparison is yet more striking, for in the products chiefly sold from Massachusetts farms the amount of potassium carried away will run from eight to ten times the amount of phosphorus.

2. Many farmers use a large amount of purchased feeds, nearly all of which are very rich in phosphoric acid. This reaches our soils in the manures from our cattle and horses. In the oats fed on the average to a pair of work horses in one year there are about 40 pounds of phosphoric acid, while in the purchased feeds for a herd of 20 cows it is probable that on the average we shall find 600 pounds of phosphoric acid.

3. The potash of animal excrements is voided mostly in solution in the urine (on the average, about four-fifths of the total). The phosphoric acid, on the contrary, is voided almost exclusively in the dung in insoluble forms. Under ordinary systems of stabling our live stock and saving manures the potash, therefore, is subject to loss in much greater degree than the phosphoric acid.

4. That the crops we principally grow take from our soils far more potash than phosphoric acid has been made apparent from what has been said of the relative proportions of these two elements in the products sold. Essentially the same relation holds for the products mainly consumed on the farm.

5. In our agriculture we have used commercial fertilizers largely for at least forty years. With few exceptions these contain much larger proportions of phosphoric acid than of potash. It is impossible to present exact figures, but it is the writer's judgment that on the average twice as much phosphoric acid as potash has been generally applied in the fertilizers used.

Does it seem likely, in view of the facts stated, that our soils are being especially depleted in phosphoric acid? This can be true only if the phosphoric acid is subject to loss from our soils under the influence of natural agencies in unusually large proportion. That this is the case is highly improbable. Phosphoric acid cannot escape into the air; and in the soil, even though soluble when applied, it soon enters into new com-

binations insoluble in water. Experiment shows that under normal conditions there is but very little loss of phosphoric acid in drainage waters.

Does it, then, seem probable that in Massachusetts agriculture, as in that of the corn-belt, phosphoric acid is the only mineral element which need be supplied?

The principal conditions having a bearing upon the tendency in our farm practice may be thus restated: —

1. In products sold from five to six times as much potash as phosphoric acid is carried away.
2. We bring in large amounts of phosphoric acid in purchased feeds.
3. Potash is far more subject to waste from animal excrements than is phosphoric acid.
4. The products of our fields, gardens and orchards all require far more potash than phosphoric acid.
5. In the commercial fertilizers so extensively used far more phosphoric acid than potash has been for years applied to our soils.

The tendency in our agriculture, therefore, must be to disproportionate consumption of potash and not of phosphoric acid.

If, however, the stock of phosphoric acid in our soils is extremely small, — far less than the stock of potash, — then it may nevertheless be true that phosphoric acid rather than potash is the principal fertilizer requirement in our agriculture.

A study of the results of such analyses of our soils as have been made is essential to the formation of a conclusion upon this point.

Composition of Massachusetts Soils.

This experiment station has published the results of analyses of 194 soil samples[1] taken in this State. These samples have come from 79 different towns and represent practically all our leading soil types. All the counties of the State except Dukes and Nantucket — the island counties — are represented.

The analyses reported have been made by the methods recommended by the American Association of Official Agricultural Chemists. These methods do not show the totals of any of the plant-food elements except nitrogen, but only the proportion which is dissolved in an acid of definite strength used at a definite temperature for a definite length of time. The results are believed to represent at least the percentages likely to become available within a generation. The table shows the average results by counties and for the entire State.

[1] See twenty-third annual report, Massachusetts Agricultural Experiment Station, p. 339.

Soil Analyses.

County.	Number of Towns represented.	Number of Samples.	N.	P_2O_5.	K_2O.	CaO.
Barnstable,	2	2	.205	.145	.170	.695
Berkshire,	3	8	.286	.242	.452	.856
Bristol,	5	16	.198	.147	.180	.643
Essex,	6	13	.518	.251	.295	.544
Franklin,	8	16	.352	.212	.306	.718
Hampden,	7	23	.253	.390	.310	.837
Hampshire,	6	21	.259	.215	.236	.704
Middlesex,	15	33	.256	.143	.213	.618
Norfolk,	8	19	.276	.187	.187	.916
Plymouth,	7	17	.312	.175	.197	.655
Suffolk,	1	9	.213	.140	.247	.416
Worcester,	11	17	.258	.250	.295	.713
Average (194 samples),	79	194	.282	.214	.252	.669

Examination of the table shows that there are but two counties in which the percentage of potash exceeds that of phosphoric acid by any considerable amount, — Berkshire and Franklin. In Berkshire there is about 90 per cent. more potash than phosphoric acid; in Franklin, about 44 per cent. more. The soils analyzed from Berkshire County have all come from three towns, — Lenox, Washington and North Adams. Those from the two former are of about the usual character, but those from North Adams are unusually rich in potash.

Eight different towns are represented in the Franklin analyses. The samples excessively rich in potash are more generally distributed. Nearly every town shows samples in which the per cent. of potash is nearly or quite double that of phosphoric acid.

The average for the State shows the proportion of the two compounds, phosphoric acid and potash, to be nearly equal, — .214 per cent. phosphoric acid and .252 per cent. potash. These figures pertain to the surface soil, the depth of which, of course, varies greatly. Assuming, however, that the average depth is 8 inches, and that the average weight of surface loams is about 80 pounds to the cubic foot, the total number of pounds of surface soil in an acre is approximately 2,300,000. The table below shows in round numbers the number of pounds each of phosphoric acid and potash in an acre of the average composition of Massachusetts soils, and for compaiison the number of pounds, in most cases as indicated by analyses made here, of each of these compounds contained in the supposed product of one acre of some of our leading crops: —

	Pounds in One Acre Surface Soil (8 Inches).	Corn; Grain, 75 Bushels; Stover 3 Tons.	Potatoes, 300 Bushels.	Timothy Hay, 2.5 Tons.	Cabbages, 20 Tons.	Onions, 800 Bushels.	Tomatoes,[1] 500 Bushels.	Asparagus, 6,000 Pounds.
Phosphoric acid (pounds),	5,000	47.26	13.68	17.10	8.00[2]	29.12	21.00	6.40
Potash (pounds), . .	5,800	107.28	91.80	73.00	136.00	74.88	105.00	20.00

[1] From Van Slyke, "Fertilizers and Crops."

[2] Most published analyses are higher for this constituent.

The totals for phosphoric acid and potash in the surface 8 inches of the average Massachusetts soil (as determined by analyses which have been made here), and shown in this table, may be compared with the requirements of large crops, also shown in the table. This comparison, made by dividing the totals in the soil by the totals in the crops, shows that there is phosphoric acid enough in the soil for from 92 to 800 crops. The potash is sufficient for from 42 to 290 crops. It is, of course, not the writer's belief that without manure or fertilizer profitable crops can be grown for the number of years which this method of calculation shows; for long before the supply of phosphoric acid or potash should become exhausted the yield would fall below the limit of profitable production; indeed, on many of the soils included in arriving at the averages presented, profitable production without the addition of both phosphoric acid and potash in manures or fertilizers is already impossible. Plants cannot "lick the platter clean."

It is generally known that the root system is by no means confined to the surface soil. Where the water table allows, most crops feed to some extent to the depth of several feet. The relation of total phosphoric acid and potash in surface soil to the amount in crops is nevertheless of interest in connection with our consideration of the applicability of the Hopkins theory of farm fertility under our conditions. The facts cited strengthen the writer's contention that potash rather than phosphoric acid is the key to profitable agriculture in most cases in Massachusetts.

RELATIVE NEED OF PHOSPHORIC ACID AND POTASH.

Experimental Results.

Full details will not be given in this paper. They will be brought together for publication in a bulletin on "Potash Requirements in Massachusetts Agriculture." Detailed reports on results from year to year in most of the experiments to which reference will here be made have appeared in bulletins and annual reports of the station.

The Potato. — The experiments which have been in progress for so

many years for comparison of different phosphates, and those for the comparison of different potash salts, make it possible to compare the effects of phosphoric acid and of potash. In each case the average increase of all the plots receiving in the one case phosphoric acid, and in the other potash, is compared with the average of the no-phosphoric acid or the no-potash plots. There are 3 no-phosphate plots and 10 receiving phosphate in the one experiment; and in the other there are 5 plots which receive no potash and 35 which do receive it. The table shows the results: —

Potatoes — Relative Effects, Phosphoric Acid and Potash.[1]

	Average Yield per Acre (Bushels).	Increase.	
		Per Acre (Bushels).	Per Cent.
Fourteenth Year (1910).[2]			
No-phosphate plots,	248.4	7.7	3.09
Phosphate plots,	256.1		
Tenth Year (1907).[3]			
No-potash plots,	197.96	57.21	29.39
Potash plots,	255.17		
Sixteenth Year (1913).[4]			
No-potash plots,	41.20	49.47	120.55
Potash plots,	90.67		

The station has carried out a few co-operative soil tests with potatoes as the crop. The results of four of these, located respectively in Marblehead, Hadley, Concord and Amherst, have been averaged, and in so far as they serve to indicate the relative need for phosphoric acid and potash for this crop the averages are here presented.[5] As is customary in soil test work[6] each plant-food element is used by itself, in combination with each of the others and in combination with both of the others. Averages will be presented showing the results of the two elements under comparison when used alone, as well as when each is used in connection with both the others. The latter figures, as will be understood, are the more significant, as each element may more fully show its effect and importance when all others are present in sufficient amounts.

[1] The number of the years as given indicates length of time the fertilizer experiment had continued. Crops have always been rotated.

[2] For details see twenty-third annual report, Part I., pp. 42-44.

[3] For full details see twentieth annual report, Part I., pp. 39-42.

[4] From unpublished results. The very small yield in this year was due chiefly to seasonal peculiarities.

[5] For details see Bulletin No. 18, Hatch Experiment Station.

[6] The plan followed in this soil test work, as well as in all the other similar work referred to in this bulletin, is given in Bulletin No. 9 of the Hatch Experiment Station.

Average Increases per Acre in Potato Crop (Bushels).

	Produced by the Use of —	
	Phosphoric Acid.	Potash.
When used alone,	8.68	43.54
When used in complete fertilizer,	7.94	60.39

The Corn Crop. — The corn crop has been used in soil test work in this station far more extensively than potatoes, and the results bear very decisively upon the question of the relative necessity of application of phosphoric acid and potash in our agriculture. In the experiments upon the south soil test acre, which have been continued from 1889 to the present time, ten corn crops have been grown.[1] The average results are shown in so far as they bear upon the question under discussion in the tables which follow: —

Average Increase per Acre in Nine[2] Corn Crops (South Soil Test).

	Produced by the Use of —			
	Phosphoric Acid.		Potash.	
	Grain (Bushels).	Stover (Pounds).	Grain (Bushels).	Stover (Pounds).
When used alone,	1.7	—39.0	26.3	2,043.3
When added to nitrate,	2.7	212.0	20.8	1,748.8
When added to the other,[3]	6.3	534.4	30.9	2,616.7
When used in complete fertilizer,	14.2	911.7	32.5	2,447.2

The crop in this field in 1913 was corn following crimson clover sown in 1912 and plowed under in the spring of 1913. The crop where phosphoric acid alone had, then, been yearly applied for twenty-five years (lime in 1899, 1 ton per acre; 1904, 1 ton per acre; and 1907, ½ ton per acre excepted) was at the following rates per acre: grain, 11 bushels (10 of which were soft), and stover, 2,180 pounds. Where potash had been used alone for the same number of years and under the same conditions the yield was grain, 52.6 bushels (7.7 of which were soft), and stover, 4,360 pounds.

[1] For full reports see bulletins and reports of the Massachusetts Agricultural Experiment Station (known as the "Hatch" Experiment Station, 1888 to 1906).

[2] The crop for 1910 is not included in figuring averages, since through accident the appropriate fertilizer was not applied in that year to one plot.

[3] That is, phosphoric acid added to potash or potash added to phosphoric acid.

The comparative results with corn surely show in a most striking way the paramount importance of potash for that crop on this soil, while it is brought out with equal clearness that the effect following the application of phosphoric acid is comparatively insignificant. It is pertinent here to call attention to the fact that the field in which these experiments have been tried is of the same character, both as to geological origin and past treatment, as the soils for which analyses showing extraordinary quantities of potash both in surface and subsoils have been made. An analysis of this soil has shown it to contain .38 per cent. acid soluble potash in the surface soil, which undoubtedly means at least 40,000 pounds total potash in the first 3 feet in depth to the acre.

It will be of interest here to inquire whether similar results should be anticipated with the corn crop in other parts of the State. The station has conducted thirty-one soil test experiments with corn in different parts of the State, every county, except Dukes and Nantucket (islands), and most of the leading soil types being covered. With hardly an exception the results have been of the same general character with those on our own grounds, and in full agreement with those as to general teaching. A few averages only will be here presented.[1]

Average per Acre in Thirty-one Corn Crops (Soil Tests).

	Increase produced by the Use of —			
	Phosphoric Acid.		Potash.	
	Grain (Bushels).	Stover (Pounds).	Grain (Bushels).	Stover (Pounds).
When used alone,	.75	8.84	10.85	902.04
When used in complete fertilizer,	5.91	265.72	12.75	1,402.57

These results, while not demonstrating so great a degree of superiority for the potash as compared with the phosphoric acid as our home experiments, still indicate that it, rather than phosphoric acid, is the element chiefly required.[2]

The Hay Crop. — A good basis of comparison of the effects, respectively, of phosphoric acid and potash upon this crop is afforded by the results upon the fields devoted to comparative trials of different phosphates (phosphate field) and of different potash salts (field G). The hay crop

[1] For details see Bulletins Nos. 9 and 18, Hatch Experiment Station, and annual reports.

[2] In our soil test experiments dissolved bone black or acid phosphate at the rate of 320 pounds per acre has always been used as the source of phosphoric acid, and muriate of potash at the rate of 160 pounds per acre as the source of potash. It is recognized that in using these amounts we are applying potash at a heavier rate per acre than phosphoric acid, — about 80 pounds to about 54 pounds. It is pointed out, however, that while the ratio of application of phosphoric acid to potash is as 1 : 1.5, the ratio of these elements in the crop is 1 : 6.7, so that phosphoric acid is applied in much the larger proportion as compared with the crop requirement.

included in the rotations which have been followed on both has included mixed timothy, redtop and red and alsike clovers. On the phosphate field materials furnishing nitrogen and potash are annually equally and liberally applied to all plots. There are 3 no-phosphate plots and 10 receive phosphoric acid. On field G there are 5 similar series of plots, each series including 1 no-potash plot and 7 receiving potash. All plots annually receive materials furnishing equal nitrogen and phosphoric acid. Average results only are here presented.[1]

Effects of Phosphoric Acid on the Hay Crop (Phosphate Field).

Year.	Yields per Acre (Pounds).				Gain.			
	No phosphate.		Average phosphate.		Per acre (pounds).		Per cent.	
	Hay.	Rowen.	Hay.	Rowen.	Hay.	Rowen.	Hay.	Rowen.
1906, . . .	6,720	1,867	7,308	1,944	588	77	8.7	4.1
1907, . . .	7,933	333	8,612	480	679	147	8.5	44.0

Effects of Potash on the Hay Crop (Field G).

Year.	Yields per Acre (Pounds).				Gain.			
	No potash.		Average potash.		Per acre (pounds).		Per cent.	
	Hay.	Rowen.	Hay.	Rowen.	Hay.	Rowen.	Hay.	Rowen.
1909, . . .	5,744	680	6,413	1,561	669	881	11.6	129.6
1910, . . .	6,240	698	6,829	1,685	589	987	9.4	141.4
1911, . . .	3,040	1,440	4,283	1,908	1,243	468	40.9	32.5

It will be noted that neither phosphoric acid nor potash produced a large increase in the first cut of the season ("hay") except in one year, 1911, when the potash appeared greatly to improve the crop. Neither, as is well understood, is the dominant requirement for either timothy or redtop which predominate in the first cut. The increase in hay produced by the potash is, however, greater even when lowest than that produced by the phosphoric acid at its best.

The far greater proportional increase in the rowen crop produced by the potash is explained by its relation to clover, which cannot be successfully produced in our soils without it. The lesser increase in the

[1] For details see annual reports for 1907, 1908, 1910, 1911 and 1912. The great variations in yield, even with full fertilization in different years, were doubtless due chiefly to seasonal variations in rainfall.

rowen crop in 1911 is doubtless explained by the fact that the original clover plants (biennial or short-lived perennials) had then for the most part died, that being the third year since seeding.

The soil test work of the experiment station affords another opportunity of comparison of the effects of phosphoric acid and potash on the hay crop (as in the other experiments with hay referred to made up of timothy, redtop and clovers). Hay has occupied our south soil test acre six years, but in only four of them was a second or rowen crop cut. The soil is rather light, the fertility only medium, even on the plots receiving a complete fertilizer, and in hot, dry summers the second growth is light.

Average Increase in Six Hay and Four Rowen Crops (South Soil Test) (Pounds).

	Produced by the Use of —			
	Phosphoric Acid.		Potash.	
	Hay.	Rowen.	Hay.	Rowen.
When used alone,	—66.7	78.8	407.1	489.5
When used in complete fertilizer,	463.3	367.5	721.7	607.5

The striking superiority in effects produced by the potash is at once apparent.

Results obtained in soil tests in different parts of the State are similar in kind, but the superiority of the yields on potash is much smaller than on our home grounds, — a consequence, in my judgment, at least in large measure, of the fact that the soils were undoubtedly in many cases acid. These experiments were all tried before the fact that so many of our soils are in need of lime was fully appreciated (1892 to 1895).

Asparagus. — We have definite data on asparagus. In our substation in Concord for asparagus investigation both phosphoric acid and potash are applied — in combination in each case with the other two plant-food elements — under conditions which make it possible to determine the specific effects. Each of the plots for which data are given has been under uniform treatment for seven years. The phosphoric acid is applied in the form of acid phosphate, and the potash in the form of muriate. The table presents the relative results of the application of phosphoric acid and potash for 1914 (the seventh year).

Asparagus — Comparative Results, Phosphoric Acid and Potash, 1914.
(Yield and Increase per Plot.[1]*)*

Acid Phosphate.

Amount applied per Plot (Pounds).	Yield.		Increase.	
	Pounds.	Ounces.	Pounds.	Ounces.
None,	404	4	–	–
15.00,	420	6	16	2
22.50,	436	15	32	11
30.00,	436	6	32	2

Muriate of Potash.

None,	366	11	–	–
8.67,	408	6	41	11
13.00,	478	15	112	4
17.33,	458	8	91	13

[1] One-twentieth of an acre.

The objection may possibly be raised — as in the case of the soil test work, in which some of the results cited for corn and other crops were obtained — that the potash being used at a greater rate per acre than the phosphoric acid, the comparison may be misleading. If, however, phosphoric acid be the element present *in minimo*, certainly even a very moderate application should give a notable increase in crop; and further, if it be the element *in minimo* and our application be too small, no amount of potash could exercise much effect, for it cannot take the place of phosphoric acid.

Yet further, in view of the facts that the ratio of phosphoric acid to potash is 1 to 3 in the crop (spring shoots), while in our applications the ratio between the two is 1 to 1.9, it can scarcely be urged that we are using phosphoric acid in disproportionately small amounts.

Soy Beans, Oats and Rye. — Soil test experiments with soy beans have given much larger increases in crop with potash than with phosphoric acid. Similar experiments with oats and rye have shown a relatively small superiority for the potash. Neither is the dominant element for these crops.

Cruciferæ. — Absolutely the only crops which have ever responded in our soil test work more largely to an application of phosphoric acid than to one of potash are those belonging to *Cruciferæ*, such as the cab-

bage, Swedish turnip and white mustard.[1] This is best shown in the results obtained on the north soil test in 1896 with cabbages. With Swedish turnips in that year the two materials gave equal increases.

Cabbages and Turnips — Increases per Acre (North Soil Test) (Pounds).

	Produced by the Use of —			
	Phosphoric Acid.		Potash.	
	Cabbage.	Turnip.	Cabbage.	Turnip.
When used in complete fertilizer, . . .	20,890	10,400	14,400	10,400

The experimental results presented appear to prove that potash application may usually be depended upon to give greater increases in most of our more important crops than phosphoric acid application. The figures given very conclusively demonstrate this for our station grounds, and, with little less conclusiveness, for widely divergent soil types in most parts of the State for potatoes, corn, hay (especially the second cut, which is usually chiefly clover) and soy beans. We know that the requirements of other legumes, including alfalfa, are in general similar to those of clovers and soy beans. We know, also, that potash application exercises a far greater effect in determining the yields of most of our fruits and garden crops than phosphoric acid application.

In view of the fact so clearly demonstrated by the figures which have been presented for our most important crops, no further argument would seem to be needed to demonstrate that phosphoric acid is not the key to "permanent" (successful and profitable) "agriculture" in Massachusetts. It is true, indeed, that our soils and subsoils contain less phosphoric acid than potash, but it is also true that under our system of agriculture the phosphoric acid has not apparently been undergoing exhaustion, and that it is not now being depleted. It is not true for most crops that phosphoric acid is the element present in our soils *in minimo*. Potash for many is the element which determines the crop more largely than any other element applied. Without the application of potash in available form, either in manures or fertilizers, the profitable production of most crops is impossible.

On the other hand, profitable crops of most kinds may be produced for a time without application of phosphoric acid. This, indeed, is not a practice which can be recommended. Such a system should be followed as will at least maintain the proportion of phosphoric acid at present existing in our soils. To reduce the percentage below its present level would for most soils and crops be a mistake.

[1] For discussion of this subject see Bulletin No. 58, Hatch Experiment Station.

Massachusetts farmers, then, should apply phosphoric acid for most crops, but certainly not to the exclusion of potash. However abundant the phosphoric acid it will not take the place of potash. However largely applied it will not reduce the necessity for the application of potash for most crops. It has no direct influence, so far as known, on the extent to which inert soil potash is rendered available. Since, however, without doubt some phosphoric acid should be applied in our ordinary farm and garden practice, the question whether, as Hopkins and his disciples believe, fine-ground rock phosphate is the best form is important. Two series of experiments in this station throw light upon the question. Both have been carried out on medium silt loams containing an average per cent. of humus and possessing excellent physical characteristics.

EXPERIMENTS FOR COMPARISON OF DIFFERENT PHOSPHATES.

The two sets of experiments designed to show the comparative effectiveness and value in agriculture of different phosphates which have been conducted here have both extended over a considerable number of years, and the conditions have been, so far as can be judged, as favorable to the activity of the more insoluble materials as will usually be found in our upland soils. The soil structure and texture are such as to favor optimum moisture conditions, and at the same time adequate aeration and good tilth. In both fields the soils were at the outset moderately acid. In the first mentioned lime at the rate of a ton to the acre was applied once during the progress of the experiment. In the other two, similar applications of lime have been made. The quantity in both fields was considerably short of that required to completely neutralize the free acids present.

In both experiments most of the principal crops common in our agriculture have found a place, and some of them for several years. In neither series of experiments has any manure been applied. In both, chemical fertilizers containing nitrogen and potash in quantities believed to be adequate for large crops have been equally applied to all plots.

In one series of experiments the basis of comparison of the phosphates used was "equal money's worth;" in the other, "equal phosphoric acid."

Comparison of Phosphates on the Basis of Equal Money's Worth.

A full account of this experiment has already been published.[1] Detailed reference to it at this time, therefore, is unnecessary. I may go further and say that any reference to the results of this series of experiments might lead to the formation of absolutely misleading conclusions. The experiment was clearly not of such a character as to afford a fair basis of comparison between the more soluble phosphates and the rock phosphates, for, as is shown by our other series of experiments as well as

[1] Fourteenth annual report, Hatch Experiment Station, pp. 24–28.

by the work of others, the more soluble phosphates exert special influences which are highly important as a result of their relatively soluble condition when applied. Any advantage which may be connected with this relatively high degree of solubility is of course largely lost, in so far as the residual phosphoric acid they contain is concerned, because of the change in the soil which converts this phosphoric acid into a much less soluble form. The true way to use dissolved phosphates, as is well understood, is not to apply at any one time in great excess of the requirements of the immediately succeeding crops, but to apply as a rule annually, in the case of hoed crops at least, in quantities more nearly equal to the immediate crop requirement.

In this series of experiments the different phosphates under comparison (dissolved bone black, basic slag meal, South Carolina rock phosphate, Florida rock phosphate and Mona guano) were applied during only four years. The experiment was continued twelve years. During this long period of time the basic slag meal gave the greatest total crop yield; the South Carolina rock phosphate ranked next, but was followed so closely by the dissolved bone black that the difference was quite insignificant in spite of the fact that the latter was used in a manner so absolutely irrational, and applied in quantity furnishing only about one-third as much phosphoric acid as was applied in the South Carolina rock phosphate. The yields on the Mona guano and Florida rock phosphate, especially on the latter, were materially below those obtained on the dissolved bone black.

It should, perhaps, be pointed out further that this experiment was continued a number of years after the crop yield on all plots had sunk below the profitable level, while there still remained in the soil of the plots which had received the rock phosphates more than two-thirds of the large amount of phosphoric acid which had been applied. At the same time, the phosphoric acid which had been applied in the dissolved bone black had nearly all been carried away in the crops.

Phosphates compared on the Basis of Equal Annual Applications of Phosphoric Acid.

This series of experiments was begun in 1897 and is still continued. We now have the results of eighteen years. The soil is a medium silt loam which had been in grass a number of years previous to being plowed for the experiment. The soil varies somewhat in physical character in different plots, but as the variation is progressive from one end of the field to the other, and the arrangement includes a no-phosphate plot at either end and one in the middle, each phosphate being compared only with the two no-phosphate plots between which it lies, and each of these being given a weight inversely proportional to its distance, it is not believed that any injustice is done to any of the phosphates in the results as presented. The more soluble phosphate plots are at the end of the field where the soil is the more heavy.

The area of the plots is one-eighth acre, — thirteen in all.

Annual Application to All Plots.

	Rate per Acre (Pounds).
High-grade sulfate of potash, [1]	300
Nitrate of soda, [2]	364
Sulfate of ammonia,	100
Hoof meal [3] (to all no-phosphate and mineral phosphate plots), [4]	102

The various forms of bone meal all contain organic nitrogen; the steamed bone usually most. To equalize conditions hoof meal is applied to each in such quantities as are required to bring the total organic nitrogen to the same amount as is furnished by the hoof meal on the other plots.

Plant-food Elements applied.

In the materials used the annual application of plant-food elements has varied somewhat with slightly varying composition of materials. One important change has been made, viz., a 50 per cent. increase in the nitrate nitrogen and in the actual potash in 1901. The annual application per plot has been substantially constant since that date, as follows: —

Plant Food applied Annually (Pounds).

	Per Plot.	Per Acre.
Nitrogen,	11.4	91.2
Potash,	19.0	152.0
Phosphoric acid,	12.0	96.0

General Treatment.

The entire field received an application of hydrated lime at the rate of one ton per acre in 1898, and again in 1914. This was spread upon the plowed land in early spring and harrowed in.

The stock of organic matter in the soil has been maintained by turning under heavy crops, as follows: winter rye in 1901, buckwheat in 1912 and rye in 1913; and by introducing grasses and clovers, 1905 to 1907, and turning under a heavy growth of grass before late cabbage in 1908.

All fertilizers have been applied broadcast in early spring, and, except when the land was in grass, on the plowed surface and disked in.

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[1] For the first two years potash-magnesia sulfate, 400 pounds; in 1899, high-grade sulfate, 400 pounds; in 1901, potash-magnesia sulfate, 400 pounds.

[2] For the first four years 250 pounds.

[3] Tobacco dust was used by accident in place of hoof meal in 1911.

[4] To all bone-meal plots an amount to make total organic nitrogen equal.

Phosphates compared and Rates per Acre.

Plot.	Materials supplying Phosphoric Acid.	Pounds per Acre.
1	None,	–
2	Arkansas rock phosphate,[1]	376
3	South Carolina rock phosphate,	376
4	Florida soft phosphate,	364
5	Basic slag meal,	538
6	Tennessee phosphate,[2]	296
7	None,	–
8	Dissolved bone black,	522
9	Raw bone meal,	404
10	Dissolved bone meal,	432
11	Steamed bone meal,	380
12	Acid phosphate,[3]	500
13	None,	–

[1] Apatite used in 1897–1905; Arkansas since 1908.
[2] Navassa phosphate used in 1897–1900; Tennessee since 1901.
[3] Owing to a clerical error in copying, which occurred in 1901, this phosphate was used only at the rate of 380 pounds per acre from 1901 to 1913, inclusive.

Crops Grown.

As already stated, the field had been continuously in grass for a long period of time previous to the beginning of this experiment. While in grass it had, during the latter part of this period at least, received moderate annual top-dressings of chemicals. The year previous to the beginning of the experiment it was plowed and planted to corn without fertilizer, with a view to noting the relative productive capacity of the different plots. The date of planting was June 27; the date of harvesting, September 26, the corn being in milk. The yields were as follows: —

Yields of Corn without Fertilizer, 1896.

Plot.	Gross Weight (Pounds).	Plot.	Gross Weight (Pounds).
1,	3,440	8,	2,905
2,	3,090	9,	2,885
3,	3,000	10,	3,555
4,	3,095	11,	2,915
5,	3,160	12,	2,990
6,	3,020	13,	2,640
7,	2,850		

It will be noted that with three exceptions the yields are quite uniform. Plots 1 and 10 are considerably above the average in productiveness, while plot 13 is about as much below.

The crops grown during the experiment in the order of their succession have been as follows: corn, cabbages, corn, oats and Hungarian grass (in 1900), onions, onions, cabbages, corn (ensilage), grasses and clovers seeded in spring (no crop harvested), hay, hay, cabbages, soy beans, potatoes, oats and alfalfa (badly winterkilled, 1911–12), buckwheat (turned under), corn and corn.

Many of the annual crop yields have been published in the reports of the experiment station, and certain averages only will be presented at this time. These will include an average for each crop on each of the three classes of phosphates into which those used somewhat naturally fall. The first class includes the natural mineral phosphates: apatite and Arkansas phosphate,[1] South Carolina rock phosphate, Florida soft phosphate and Navassa and Tennessee phosphates;[2] the second class includes basic slag meal, raw bone meal and steamed bone meal; the third class, dissolved bone black, dissolved bone meal and acid phosphate.

The yields for the first two years have not been included in figuring these averages, as it is apparent that initial inequalities in productive capacity exercised a considerable influence in determining yields. It is not unlikely that such inequalities continued for some time (possibly they still continue to exercise some influence), but it is believed that the manner of computing increases due to the several phosphates previously described[3] has so reduced the influence of such inequalities that the averages of results extending over so long a term of years present a reliable basis for determining the relative crop-producing value of the different classes of phosphates.

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[1] Apatite from 1897–1905; since 1908, Arkansas.

[2] Navassa phosphate from 1897–1900; since 1901, Tennessee.

[3] See p. 148.

Increases per Acre in Crops produced by Different Classes of Phosphates.

	Natural Mineral Phosphates.		Basic Slag and Bone Meals.		Dissolved Phosphates.	
	Bushels.	Pounds.	Bushels.	Pounds.	Bushels.	Pounds.
Corn, three years, 1899, 1913, 1914: —						
Grain, ...	—1.06	-	8.03	-	9.96	-
Stover, ...	-	318.87	-	905.50	-	651.11
Hay, two years, 1906, 1907: —						
Hay, ...	-	398.30	-	615.55	-	753.33
Rowen, . . .	-	—131.00	-	97.33	-	350.67
Total, ...	-	267.30	-	712.88	-	1,104.00
Onions, two years, 1901, 1902: —						
Sound, ...	—30.60	-	143.60	-	136.73	-
Scallions, . . .	10.76	-	—19.23	-	—12.56	-
Cabbage, two years, 1903, 1908, ...	-	9,817.50	-	21,026.60	-	18,758.60
Oat hay, one year, 1900, .	-	231.70	-	1,324.40	-	1,520.00
Hungarian hay, one year, 1900, ...	-	166.70	-	—222.23	-	—253.30
Ensilage corn, one year, 1904, ...	-	—1,638.70	-	7,608.90	-	7,361.30
Soy beans, one year, 1910: —						
Grain, ...	.77	-	4.09	-	3.87	-
Straw, ...	-	290.56	-	794.67	-	776.00
Potatoes, one year, 1910: —						
Marketable, . . .	—10.70	-	16.40	-	26.90	-
Total, ...	—8.30	-	18.90	-	29.50	-
Oat and alfalfa hay, one year, 1911, . .	-	80.00	-	1,626.67	-	1,560.00
Alfalfa hay, one year, 1911,	-	91.70	-	244.40	-	73.30

The table makes it strikingly apparent that the natural mineral (rock) phosphates used in this series of experiments have produced much smaller average increases in crops than those of the other classes. For the purpose, however, of bringing out the relative effects more clearly the results have been figured on a percentage basis shown in the table below: —

Phosphate Field, 1899–1914. Increase over No-Phosphate Plots in Per Cent.

	Natural Mineral Phosphates.	Basic Slag and Bone Meals.	Dissolved Phosphates.
Corn, three years: —			
Grain,	—1.48	12.89	17.03
Stover,	5.83	17.74	13.22
Hay, two years: —			
Hay,	5.28	8.38	10.41
Rowen,	—11.34	8.64	31.88
Total,	3.08	8.42	13.24
Onions, two years: —			
Sound,	—17.75	137.35	160.10
Scallions,	12.86	—25.04	—16.56
Cabbage, two years (total),	116.01	288.30	278.32
Oat hay, one year,	4.22	27.62	33.63
Hungarian hay, one year,	4.30	—5.68	—6.46
Ensilage corn, one year,	—4.42	25.99	28.00
Soy beans, one year: —			
Beans,	2.54	14.38	14.00
Straw,	10.43	35.88	38.26
Potatoes, one year: —			
Marketable,	—4.00	6.84	11.72
Total,	—2.97	7.49	12.12
Oats and alfalfa hay, one year,	2.00	47.28	49.37
Alfalfa hay, one year,	11.49	32.35	9.40

1. The tabulation of averages shows that, with one exception, the percentage increases in crops of all kinds produced by the natural mineral phosphates are far smaller than those produced by the other classes of phosphates. The single exception is Hungarian hay grown as a second crop in 1900 without a second application of fertilizers. This exception, therefore, has no special significance in its bearing upon the relative efficiency of the classes of phosphates under consideration.

2. It will be noted that in a number of cases the averages for the slag and bone meals are higher than for the dissolved phosphates. It should be pointed out that in two respects the materials in the former class differ from those in the latter: (1) the slag meal furnishes some free lime and a considerable excess of lime in neutral combinations; (2) the bone meals supply some nitrogen in organic combinations.

It has been pointed out[1] that an attempt to equalize the organic nitrogen of the bone meals was made by the addition of hoof meal to the plots receiving other phosphates. It is generally held that the availability of the organic nitrogen in bone meals and in hoof meal is substantially equal, but in some experiments this has not seemed to be the case. No doubt the availability in both is much affected by fineness of grinding.

[1] See p. 149.

No effort was made to equalize the lime supply on the different plots, although the fact that the entire field was limed twice at the rate of a ton to the acre as already described[1] reduces the probability that the excess of lime in the slag exercised an important influence. The possibility, however, that the occasional superiority of the slag and bone meals may have been due to the factors referred to should not be overlooked.

3. It should be noted that the more soluble phosphates, while not increasing the stover of the corn crop so largely as the slag and bone meals, exercise a more favorable influence upon the production of grain.

4. This is doubtless, at least in part, due to the fact that the more soluble phosphates promote more rapid early growth and earlier maturity than do those less soluble.

(*a*) *More Rapid Early Growth.* — The marked effect of an application of soluble or quickly available phosphates upon the early growth of the corn crop has been many times observed.[2] We have made measurements only once in this series of experiments, viz., in 1914. These measurements were made on July 10, and indicate the extreme height from the ground to the highest leaf-tip. The figures are the averages of 40 plants in each plot, — equidistant individuals each in the fourth and seventh rows.

Height on July 10.

Plot.	Fertilizer.	Inches.	Plot.	Fertilizer.	Inches.
1	No phosphate, . . .	32.23	8	Dissolved bone black, .	42.15
2	Arkansas phosphate, . .	28.92	9	Raw bone meal, . .	40.02
3	South Carolina phosphate,	30.83	10	Dissolved bone meal, .	38.79
4	Florida soft phosphate, .	32.62	11	Steamed bone meal, . .	40.20
5	Slag meal phosphate, .	35.67	12	Acid phosphate, . .	42.05
6	Tennessee phosphate, .	32.99	13	No phosphate, . . .	29.69
7	No phosphate, . . .	30.96			

The great superiority of the soluble phosphates and the bone meals is clearly brought out by this table, while the average measurement indicates the slag meal to be materially superior to the natural phosphates in its effect upon the early growth.

(*b*) In favorable years varieties of corn suited to the locality attain maturity on all plots; but in years with summer temperatures much below the average, or those with early autumn frosts, a part of the crop fails to ripen completely. This was notably the case in 1913, in which year the thermometer fell to 31° at 6 A.M. on September 15. The percentages of soft corn were lowest on the slag meal and dissolved bone, —

[1] See p. 149.

[2] On our north corn acre acid phosphate has been used during the past twenty-five years at widely varying rates on different plots; in round numbers 1,100 pounds per acre on two plots, and 200 pounds per acre on two. During the first few weeks the growth on the plots receiving the larger application of acid phosphate is always far more rapid than on the other plots.

30 and 44 per cent., respectively; they were highest on the South Carolina rock, 87 per cent.; the average for all the natural rock phosphates was 63 per cent.; for the no-phosphate plots it was 71 per cent. The proportions of soft corn on the different plots were in my judgment affected by the physical differences in the soil of the plots, but there can be no doubt as to the general effect.

In 1914 the summer temperature was below the normal, but the crop was cut and shocked before frost. There was, however, some soft corn. The percentages were: no-phosphate plots, 12; natural rock phosphate plots, 9; slag, bone meal and soluble phosphate plots, 5.

5. The effect of the more soluble and available phosphates in promoting maturity is strikingly apparent, also, in the case of the onion crop grown in this series of experiments. The presence of scallions indicates imperfect maturity. Two onion crops have been grown in this experiment, — 1901 and 1902. Neither gave a satisfactory yield, and the proportion of scallions on all plots was much larger than normal, in my judgment, due in part to the fact that the field is not sufficiently heavily fertilized for the crop, and in part to the unfavorable physical characteristics which, as already pointed out, vary considerably on the different plots. The greater proportion of scallions on the rock phosphates shown in the following table is the more significant for the reason that in the plots where these were used the physical conditions were more favorable than on the other plots. The steamed bone meal, dissolved bone meal and acid phosphate plots have not been used in computing the averages shown because of the very unfavorable soil texture of these plots for the onion. The fact that the acid phosphate had been applied in only about one-half the amount needed to furnish equal phosphoric acid constituted a second reason for the omission of this plot.

Proportion of Scallions in Onion Crop (Per Cent. of Total).

	No-Phosphate Plots.	Dissolved Bone Black, Slag and Bone Meal.	Natural Rock Phosphates.
1901, ...	15	7	15
1902, ...	59	29	66

6. The relation between hard and soft heads in the cabbage crops grown in these experiments points also to the conclusion that the more soluble and available phosphates promote rapid early growth and maturity. In all cases there have been more soft heads on the no-phosphate and the rock phosphate plots than on the others. The slag plot has been among the best in the quality, solidity and weight of the crop. Full details have been published and figures will not now be given.[1]

[1] For relative weights, soft and hard heads, see sixteenth annual report, Hatch Experiment Station, p. 136. For crop in other years see eleventh and twentieth annual reports.

Relative Profits on the Different Phosphates.

The results presented fully establish the facts of larger relative increases and in some instances superior quality of crops on the more soluble and available phosphates. Clearly, therefore, the use of such phosphates rather than the fine-ground natural rock phosphates is the part of wisdom, unless the cost of the latter is so much lower that they allow greater profit on their use than do the more soluble phosphates, in spite of the greater crop increases on the latter. The table gives the differences in value between the average annual crop increases and the average cost for the different classes of phosphates.

Gain or Loss per Acre in Crop Values compared with Cost of Phosphates.

	Natural Mineral Phosphates.	Basic Slag and Bone Meals.	Dissolved Phosphates.
Cost of phosphates,	$3 67	$3 70	$3 24
Corn, average of 3 crops, 1899, 1913, 1914: —			
Grain,	—$0 79	$6 02	$7 47
Stover,	95	2 72	1 95
Total,	16	8 74	9 42
Hay, average of 2 crops, 1906, 1907: —			
Hay,	3 19	4 92	6 03
Rowen,	— 79	58	2 10
Total,	2 40	5 50	8 13
Onions, average of 2 crops, 1901, 1902 (sound),	—15 30	71 80	68 36
Cabbage, average of 2 crops, 1903, 1908,	58 91	126 16	112 55
Oat hay, 1 crop, 1900,	1 39	7 95	9 12
Hungarian hay, 1 crop, 1900,	1 00	—1 33	—1 52
Total,	2 39	6 62	7 60
Ensilage corn, 1 crop, 1904,	—6 55	30 44	29 44
Soy beans, 1 crop, 1909: —			
Beans,	2 31	12 27	11 61
Straw,	87	2 38	2 33
Total,	3 18	14 65	13 94
Potatoes, 1 crop, 1910: —			
Merchantable,	—6 42	9 84	16 14
Small,	48	50	52
Total,	—5 94	10 34	16 66
Oats and alfalfa, 1 crop, 1911,	48	9 76	9 36
Alfalfa, 1 crop, 1911,	83	2 20	66
Total,	1 31	11 96	10 02
Annual average,	$6 21	$36 23	$34 57

The results shown in this table are overwhelmingly conclusive on the point under discussion. The values of the crop increases in all instances exceed the cost of phosphate many times more on the more soluble and available materials than on the natural rock phosphates. The latter afford, therefore, far lower profits on their use than the former.

Cumulative Effect.

The advocate of the use of the rock phosphates may at this point urge that while such phosphates are at first less effective than the more soluble and quickly available materials they will ultimately fully equal the latter. This series of experiments has now continued eighteen years, and it would seem that this result should have been already realized. This has not been the case. The more soluble phosphates, bone meal and slag, still annually exceed the rock phosphates greatly in their effect on crop yield. Such excess, so far as can be judged, is still as great as at any earlier period. The corn crop affords the best chance of comparison, having been grown in 1899 and in 1914. The increases in crop per acre in the two years are shown below: —

Corn Crop — Increases per Acre, with Different Phosphates.

	Natural Rock.		Slag and Bone Meals.		Dissolved Phosphates.	
	Grain (Bushels).	Stover (Pounds).	Grain (Bushels).	Stover (Pounds).	Grain (Bushels).	Stover (Pounds).
1899, . . .	—2.410	113.3	1.27	—127.8	5.03	—493.3
1914, . . .	—0.175	243.3	13.27	1,808.9	15.37	1,460.0

These figures show greater increases in the corn crop on all classes of phosphates in 1914 than in 1899. Such increases, however, are insignificant for the natural rock phosphates, while for the slag, bone meals and soluble phosphates they are large. The latter excel the rock phosphates in 1914 in much greater degree than in 1899. The conclusion, therefore, seems justified that the natural agencies at work in this soil are not in any marked degree increasing the availability of the natural mineral phosphates. In the eighteen years during which this series of experiments has continued we have supplied 1,728 pounds of phosphoric acid per acre to the soil of these phosphate plots.[1] In the crops harvested from the rock phosphate plots, supposing them to have been of average composition, we have removed about 450 pounds. There has therefore been a large excess of phosphoric acid applied (about 1,275 pounds per acre), and still the amount available is insufficient to give maximum crops. The yields are far below those obtained on the slag, bone meals and dissolved phosphates.[2]

It is well understood that a large proportion of organic matter in the soil is favorable to the activity of the raw phosphates. In commenting on the results obtained in these experiments in his book "Soil Fertility

[1] Two exceptions have been noted, p. 150: plot 2, on which the shortage is 192 pounds, and plot 12 on which it is about 240 pounds.

[2] These also must have furnished phosphoric acid in much larger quantities than have been removed in the crops.

and Permanent Agriculture,"[1] published in 1910, Dr. Hopkins says: ". . . no provision was made for maintaining organic matter in the soil."

In view of the facts that a heavy crop of winter rye was plowed in in 1901, and after three years in hay (1905–07), a heavy growth of grass before late cabbage in 1908, it is believed the supply of organic matter had been well maintained. Certainly in our experience we have not only fully maintained, but actually increased, productiveness on soils of similar character by use of fertilizers only, under systems of management less favorable to the maintenance of the humus content. It is not believed there could have been a shortage of organic matter in the soil of these plots at the time when Dr. Hopkins wrote. Wishing, however, to create conditions as favorable as possible to the action of the raw phosphates, two heavy green manure crops have since been grown and plowed in, — buckwheat in 1912 and winter rye in 1913. It has been shown that in spite of this treatment not only is the increase in crops from the raw phosphates still less than from the others, but it seems to be falling still further behind.

INDIRECT OR SECONDARY EFFECTS.

The no-phosphate plots in this series of experiments have given crops which, as shown by calculation on the basis of average composition, have carried away nearly as much phosphoric acid as has been carried away in the crops of the phosphate plots. The totals of this element for these plots exceed the totals for the plots receiving no phosphoric acid, as follows: —

Phosphoric Acid in the Total Increases in Crops.

	Per Plot (One-eighth Acre) (Pounds).
Natural fine ground rock phosphates,	1.06
Slag and bone meals,	8.43
Dissolved phosphates,	8.63

If the crops on the phosphate plots have drawn upon the natural soil supply of phosphoric acid as largely as those on the no-phosphate plots, then the proportion of the phosphoric acid applied in these experiments which has been removed by the crops is extremely small, — indeed quite insignificant. As phosphoric acid is not subject to much if any loss from soils by leaching, it would seem that nearly all of this element which has been applied must still remain in the soil, even in those plots to which it has been applied in the more soluble forms.

In spite of this fact the use of the slag, bone meals and dissolved phosphates has given increases in crops which much more than cover the cost of the phosphates used as shown by the table on page 156. In view of this fact it appears probable that the benefits following their use must have been due in considerable measure, to indirect or secondary effects rather than to the direct plant-food action of the phosphoric acid they contained. One of these indirect effects — the stimulation to rapid

[1] Page 283.

early growth — has already been referred to.[1] There is considerable evidence which tends to show that there are several other indirect or secondary effects of importance.

Effect on Soil Acidity.

Most of the secondary effects are believed to be beneficial, but the question is frequently asked whether the use of dissolved (acid) phosphates will not exercise an injurious secondary effect through making soils sour. Those advocating the use of natural rock phosphates usually call especial attention to this effect. Thus, Hopkins says: "A third point in favor of raw phosphate, in common with bone and slag, is that it is free from acidity and has no tendency to injure the soil."[2] In the following sentence he asserts that acidity does develop from continued use of acid phosphate, but adds that it can be corrected at small expense by the use of lime.

The writer cannot point to results of chemical investigations in connection with his work which either prove or disprove the correctness of this assertion, that continued use of acid phosphate increases soil acidity. No such investigations have been undertaken. In some of his experiments, however, lime has been so applied as to afford opportunity to note the relative benefit as indicated by crop yield under otherwise similar conditions on plots over a long series of years, respectively, without and with application of an acid phosphate (dissolved bone black). If the dissolved bone black used continuously had increased acidity in any marked degree, it would follow that crops to which acid is toxic would show greater benefit from liming on the plots to which dissolved bone black was annually applied than on those plots not receiving it. In a long-continued series of soil test experiments,[3] where one-half of all plots has been limed, this

[1] See p. 154.

[2] "Soil Fertility and Permanent Agriculture," p. 242.

[3] This series of experiments was begun in 1890 and has continued to date. Nitrate of soda, dissolved bone black and muriate of potash have each been applied annually, as shown by the table.

Plot.	Materials applied.	Rates per Acre (Pounds).
1,	Nothing,	–
2,	Nitrate of soda,	160
3,	Dissolved bone black,	320
4,	Nothing,	–
5,	Muriate of potash,	160
6,	Nitrate of soda,	160
	Dissolved bone black,	320
7,	Nitrate of soda,	160
	Muriate of potash,	160
8,	Nothing,	–
9,	Dissolved bone black,	320
	Muriate of potash,	160
10,	Nitrate of soda,	160
	Dissolved bone black,	320
	Muriate of potash,	160
11,	Plaster,	400
12,	Nothing,	–

In 1899 one-half of all plots received an application of lime at the rate of one ton per acre; in 1904 a second application was made to the same halves at the rate of 2,300 pounds per acre; and in 1907 a third application at the rate of 1,000 pounds per acre.

has not been the case. The benefits following liming are with all crops greater without dissolved bone black than under otherwise similar treatment with it. In other words, the use of dissolved bone black appears to have decreased the necessity for lime.

Need of Lime as indicated by Relative Crop Increase after Liming.

	Muriate of Potash.		Nitrate of Soda and Muriate of Potash.	
	With Bone Black.	Without Bone Black.	With Bone Black.	Without Bone Black.
Corn, 1905: —				
Grain,	100	365	100	192
Stover,	100	1,363	100	36
Hay, four years, 1903, 1904, 1908, 1909,	100	207	100	101
Soy beans, three years, 1906, 1910, 1911: —				
Grain,	100	350	100	108
Straw,[1]	100[2]	32[2]	100[2]	90[2]

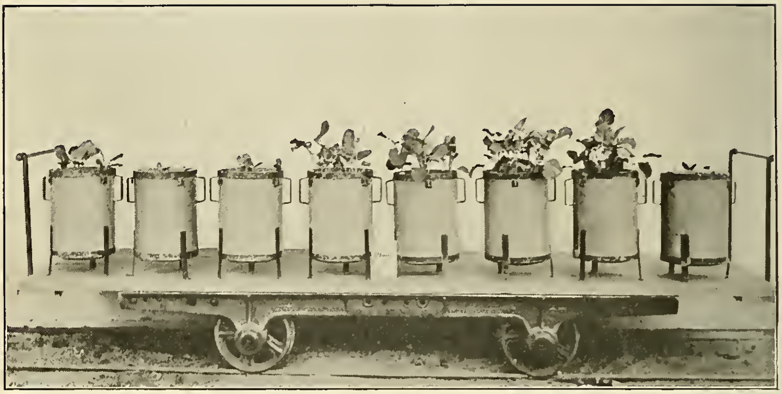
[1] Compared on the basis of relative decrease.
[2] Relative decrease where lime was applied.

It must be remembered in studying this table that the increases (or decreases) compared are, first, those under the treatments indicated by the headings of the first and second columns of figures; and second, those indicated by the headings of the third and fourth columns. The figures do not indicate the relations between these two pairs of plots (plots 5 and 9 and plots 8 and 10). It will be noticed that with one exception these results are perfectly concordant. The use of lime produces, with this one exception, a larger increase (or a smaller decrease) when used without dissolved bone black than when used with it. The exception is the effect upon the stover of the corn crop on nitrate of soda and muriate of potash. No explanation can at this time be offered; but it is made quite apparent by the smaller relative increases (and the larger relative decrease in one case) produced by lime without bone black when the latter is added to nitrate of soda and muriate of potash than when it is added to muriate of potash alone that the soda of the nitrate decreases the necessity for lime, — a fact which is generally understood.

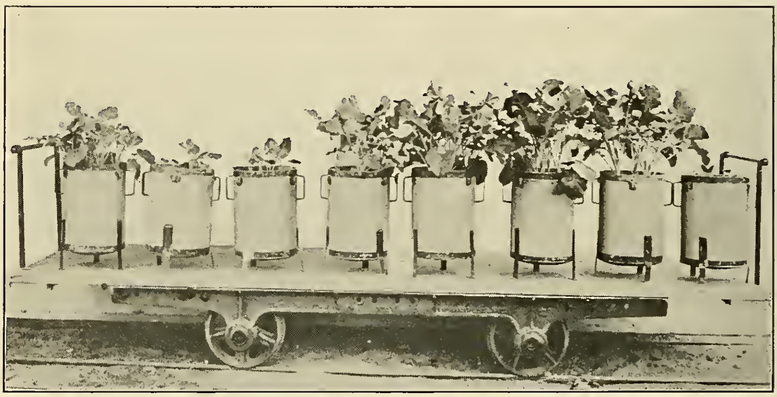
It would seem to be thoroughly established by the results of these experiments that the use of an acid phosphate (dissolved bone black) at least has not increased the necessity for lime. On the contrary, it seems clear that the bone black has reduced this necessity.

Sulfur supplied.

It is recognized that considerable quantities of sulfur, in the form of calcium sulfate, have been applied to the plots receiving dissolved phosphates, and that the plots with which these have been compared have



Comparative test of phosphates, Dwarf Essex rape. Cubic capacity of pots, .545 cubic feet; weight of earth, about 17 kilograms at 12 per cent. moisture. All pots received equal and abundant nitrogen and potash. Where supplied, phosphoric acid per pot equals .41 gram. From right to left: no phosphate, dissolved bone black, acid phosphate, dissolved bone, steamed bone meal, South Carolina rock phosphate, Florida rock phosphate, basic slag phosphate (meal).



Comparative test of phosphates, Dwarf Essex rape. Cubic capacity of pots, .545 cubic feet; weight of earth, about 17 kilograms at 12 per cent. moisture. All pots received equal and abundant nitrogen and potash. Where supplied, phosphoric acid per pot equals .82 gram. From right to left: no phosphate, dissolved bone black, acid phosphate, dissolved bone, steamed bone meal, South Carolina rock phosphate, Florida rock phosphate, basic slag phosphate (meal).

received no such application. It may possibly be urged that this sulfur has been beneficial. This of course is possible, although numerous other lines of experiment carried on by the writer which afford opportunities for comparison fail to demonstrate any necessity for the application of sulfur.

Beneficial Secondary Effects from the Use of Soluble Phosphates.

Among secondary effects which appear to be generally admitted to follow application of soluble phosphates may be named the following: rapid early growth both of roots and tops, increase in tillering in grains and grasses, earlier and therefore often more perfect ripening, increase of the availability of certain soil constituents, and larger acquisitions of atmospheric nitrogen.

1. *Rapid Early Growth of Both Roots and Tops.* — Many observers have noticed the quick start which plants from seed make when dissolved phosphates have been applied. Attention has been called to the differences in rate of development of the corn crop in the experiment comparing different phosphates.[1] In numerous other experiments which have been carried out here similar differences have been observed. Especially striking have been the results obtained with rape and cabbages both in field and pot experiments. Differences about as great have been noted in the case of soy beans and millet.

The fact that the differences in early root development are perhaps even more striking than in early top development has not been demonstrated in our experiments, but Hall,[2] points out that Sir John Lawes called attention to this effect more than sixty years ago. He refers to a water culture which demonstrates it, and suggests that this effect accounts for the extraordinary results often following even small applications of soluble phosphates. He states that an application of half a hundred weight per acre of superphosphate in Australia to soils not signally deficient in phosphoric acid often doubles the yield of cereals, and expresses his belief that the result is due to the stimulating action of the phosphoric acid upon the young roots. He points out that this action is particularly important in that semi-arid country because as a result the plant quickly gets its roots down into the cooler and moister subsoil upon which the yield of the crop largely depends.

This stimulation of early root development must be a very great benefit under the conditions of our agriculture and in our climate. The crop which early develops an extensive root system — both deep and broad — can much better resist our frequent drouths than one whose roots develop more tardily. It is apparent, also, since it is known that roots by direct and intimate contact with soil particles exercise an important influence in supplying the plant with food, that the more extensive the root development the more largely the plant will be able to utilize the resources of the soil itself.

[1] See p. 154.

[2] "Fertilizers and Manures," p. 140.

The stimulation to rapid early development under discussion is especially important in the case of all crops with which it is for any reason unusually difficult to secure a perfect stand, whether from a habit of growth naturally slow and feeble at first, or from the fact that the seedlings are peculiarly subject to insect injury. The beet is an example of the first; the Swedish turnip of the second. In the cultivation of either table, sugar or mangel beets, and of all crops of the turnip or cabbage family, the use of soluble phosphates is highly important to enable them both to outgrow weeds and to withstand the attacks of flea beetles and aphids.

2. *Increase in Tillering of Cereal Grains.* — As cereal grains are quite unimportant in our agriculture no direct observations which demonstrate that the cereal grains tiller or "stool" more freely when soluble phosphates are applied have been made in our experiments. There seems, however, to be no doubt of the fact. Hall asserts it in the following words: "Both in the field and in pot experiments the phosphoric acid has a great effect in promoting the formation of adventitious buds, so leading to the tillering of the plant."[1] The beneficial effects of phosphates in top-dressing for hay are very likely associated in part with a similar effect, which should mean a closer turf and a thicker and heavier yield. The millets and Hungarian grass should, it would seem, show a similar influence.

3. *Earlier and More Perfect Ripening.* — The facts that in our experiments the more soluble phosphates have produced a larger proportion of sound and perfectly ripened corn and a larger proportion of well-ripened onions than the natural rock phosphates have been pointed out.[2] The more soluble phosphates in these experiments have also produced much the larger proportion of hard (mature) heads of cabbage. The fact that soluble phosphates in abundance favor perfect and relatively early maturity has been too often observed and is too well known to need demonstration.

With any crop, therefore, subject to possible frost injury in autumn, a free use of the more soluble and available phosphates should be the rule. In the case of garden crops, also, for which the price is usually much higher for the earliest product, the rule should be the same. A single day with such products as peas, sweet corn, tomatoes and many others which might be mentioned often means the difference between a large profit and a price which perhaps barely covers cost. The gardener, other things being equal, who uses soluble phosphates within reasonable limits most freely will be first in market with his product. No amount of previous use of natural rock phosphate can produce the same effect, for the phosphoric acid of these is not sufficiently soluble to exercise the required stimulation.

The superior color of fruits — especially of the apple — produced by trees in soils to which available phosphates have been freely applied is

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[1] "Manures and Fertilizers," p. 139. [2] See pp. 154–155.

doubtless only a special illustration of this hastening effect on the ripening process. This effect on color has perhaps most frequently been attributed to the application of basic slag meal. It is, of course, understood that many other conditions also affect color.

4. *Effect on the Availability of Soil Constituents.* — That the action of the soluble phosphates in the soil increases the availability of some of the important soil constituents seems to be generally held. This is a point which has not been made the subject of special investigation here. That it will make it possible for the plant to draw more largely upon the soil because of the increase in root development which it causes has been pointed out.[1] Aside from this it is believed that the soluble phosphates exert a direct chemical effect which results in bringing some of the soil constituents more largely into solution. All soluble phosphates contain calcium sulfate (land plaster), and this compound is held by many to be the constituent of acid phosphate most active in decomposing the complex silicates of the soil and rendering the potash they contain soluble and available to crops. Long-continued experiments in the use of land plaster, which have been connected with soil tests continued for twenty-six years have not given very material increases in crops which respond in marked degree to an application of muriate of potash alone. The average increase in 13 corn crops grown in this soil test during the twenty-six years, due to the annual application of muriate of potash at the rate of 160 pounds per acre, has been 27 bushels, while the average increase due to the annual application of plaster at the same rate has been 2½ bushels. It seems clear that had the plaster exercised a very important influence in making the potash of the soil (present in this case in very large amounts) available there must have been a larger increase in the corn crop following its use.

The use of superphosphate has been shown to be favorable to nitrification,[2] and must therefore increase the availability of the organic nitrogen-containing soil constituents.

It has been asserted that some of the constituents of acid phosphate act as catalytic agents in the soil, and by their action render soil constituents available; but that this is the case does not appear to have been fully established. On the whole, therefore, it seems to the writer that the direct chemical influence of soluble phosphates as affecting the availability of soil constituents is less important than the other secondary effects which have been considered.

5. *Larger Gain of Atmospheric Nitrogen.* — It has been demonstrated that the activity of bacteria which have the ability to fix atmospheric nitrogen in the soil is increased by the application of superphosphates, and that as a consequence more nitrogen is brought within reach of the crop and a larger yield usually obtained.[3]

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[1] See p. 161.
[2] Abst. E. S. R., Vol. XXVIII., p. 216: Patterson & Scott Jour. Dept. Agr. Victoria, 10 (1912).
[3] Abst. E. S. R., Vol. XX., p. 621: Löhnis & Pillai, Centbl. Bakt. 2 Abt. 20 (1908), No. 24–25.

CONCLUSIONS.

The principal points which have been presented that have a bearing upon the questions affecting the need and selection of phosphates will now be summarized. It is believed all are either well grounded in general knowledge and experience, supported by results of our own experiments reported in earlier pages, or established by the experiments of others.

1. The products chiefly sold from Massachusetts farms contain relatively little phosphoric acid; potash is contained in them in far larger proportion, usually from four to six times as much.

2. Most farmers use purchased stock or horse feeds rich in phosphoric acid, and thus greatly enrich the manure made in that compound.

3. Phosphoric acid is subject to much less waste from accumulating manures under usual conditions than potash.

4. The crops grown in our farm, garden and orchard practice all take from the soil far more potash than phosphoric acid.

5. The fertilizers in general use for the past fifty years have supplied far more phosphoric acid than potash.

6. Phosphoric acid is subject to extremely little loss from soils by leaching.

7. It seems clear from the preceding statements that under our system of agriculture our soils are not being depleted in phosphoric acid.

8. Chemical analysis of our leading soil types by conventional methods shows that the percentages of acid soluble phosphoric acid and potash are usually nearly equal; averages for the State, phosphoric acid, .214 per cent.; potash, .252.

9. If all of these compounds found in our average surface soil by conventional methods of analysis could be utilized —

The phosphoric acid would (according to crop) last from ninety-two to eight hundred years.

The potash would (according to crop) last from forty-two to two hundred and ninety years.

10. The total potash in the surface soil very materially exceeds the total phosphoric acid, and acid soluble potash is usually much more abundant in subsoils than phosphoric acid.

11. In spite of the relatively greater stock of total potash in soils than of total phosphoric acid, an application of the former in soluble forms in fertilizers has produced larger crop increases than has a similar application of phosphoric acid for the following: asparagus, potatoes, corn, hay, clover and soy beans. The only crops giving larger increases on phosphoric acid are crucifers (turnips, cabbages, etc.).

12. The results of hundreds of experiments at this station and in various parts of the State indicate that phosphoric acid is not the key to "permanent" (successful and profitable) "agriculture" in Massachusetts. It is not usually the element *in minimo*. Potash, as measured by crop requirements, is more often *in minimo*, and determines the yield.

13. The phosphoric acid capital in our soils is certainly not too large; doubtless it should in many cases be increased. Phosphates should be used in our agriculture, and the question whether the natural rock phosphates should be employed is an important one.

14. In experiments which have continued eighteen years, in which various fine-ground mineral phosphates, bone meals (raw, steamed and dissolved), slag meal, dissolved bone black and acid phosphate have been compared on the basis of equal annual liberal application of phosphoric acid, the results have been highly unfavorable to the natural mineral phosphates with all important crops.

15. The percentage increases (of all crops, 1899 to 1914, inclusive) show the following averages: —

	Per Cent.
Natural mineral phosphates,	9.13
Slag and bone meals,	42.24
"Dissolved" phosphates,	44.85

16. The "dissolved" phosphates are much more favorable to rapid early growth than the natural mineral phosphates.

17. The "dissolved" phosphates favor ripening, as shown by the smaller proportions of immature product, especially with corn, onions and cabbages.

18. The increases in crops produced by the slag, bone meals and "dissolved" phosphates exceed cost of the materials in much greater degree than is the case with the natural mineral phosphates. The average figures are, per acre: —

For natural mineral phosphates, annually,	$6 21
For slag and bone meals, annually,	36 23
For "dissolved" phosphates, annually,	34 57

19. The natural mineral phosphates gave yields after eighteen years' continuous use, yet more inferior as compared with the dissolved phosphates than in the earlier years. The increases for the corn crop are, per acre: —

	Bushels.	
	1899.	**1914.**
Natural mineral phosphates,	—2.41	—0.175
Slag and bone meals,	1.27	13.270
"Dissolved" phosphates,	5.03	15.370

20. It is clear that the natural agencies active in the soil in these experiments act upon the mineral phosphates with extreme slowness, in spite of the fact that large amounts of organic matter have been incorporated with it by the growth and turning under of green crops.

21. The fact that increases in crops, even on the dissolved phosphates, account for only a very small proportion of the total phosphoric acid applied — less than 10 pounds out of 216 per plot — indicates that the favorable effects were due chiefly to indirect causes.

22. The dissolved phosphates greatly stimulate early root and top development. This action is of great importance in enabling the crop to draw more largely upon the soil both for water and food, and in enabling some crops to resist insect injury.

23. Dissolved phosphates are reported to favor tillering (stooling), and this means a thicker growth of grains, grasses and millets.

24. Dissolved phosphates favor early and perfect ripening, and are therefore much to be preferred where earliness is desirable and in case of crops liable to autumn frost injury.

25. Dissolved phosphates, chiefly through the activity of the calcium sulfate which they contain may somewhat increase the availability of soil potash.

26. The use of dissolved phosphates has been shown to be favorable to nitrification, and to larger gain in atmospheric nitrogen acquired through the activity of soil bacteria.

27. Finally no injurious secondary effects are known to be associated with any reasonable use of dissolved phosphates. Our experiments indicate that they do not increase the necessity for the use of lime.

Massachusetts farmers, gardeners and orchardists are advised against the general use of raw rock phosphates. In so far as they are needed in our agriculture the phosphates employed should be the more soluble and available kinds, such as acid phosphate (dissolved rock), dissolved bone, basic slag meal and bone meals. The dissolved forms are advised for a quick start and early maturity. The mixed fertilizers upon our markets usually contain a large proportion of phosphoric acid chiefly in soluble and available forms. The station bulletins show their character. Those high-grade fertilizers with a large proportion of water-soluble phosphoric acid will be most favorable to a quick start and early maturity.

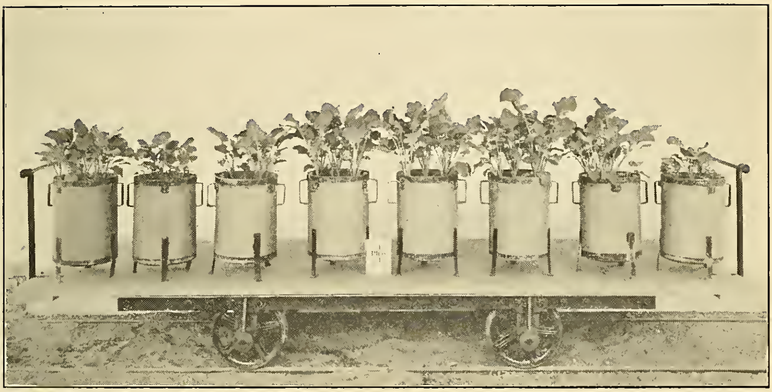
Natural rock phosphates are unadapted to the conditions of our agriculture, and their use will, with most of our crops and on most soils, give highly unsatisfactory results. What is needed in our agriculture is frequent (in case of many of our hoed crops, annual) applications of dissolved or quickly available phosphates.

Relative Phosphate Needs of Different Crops.

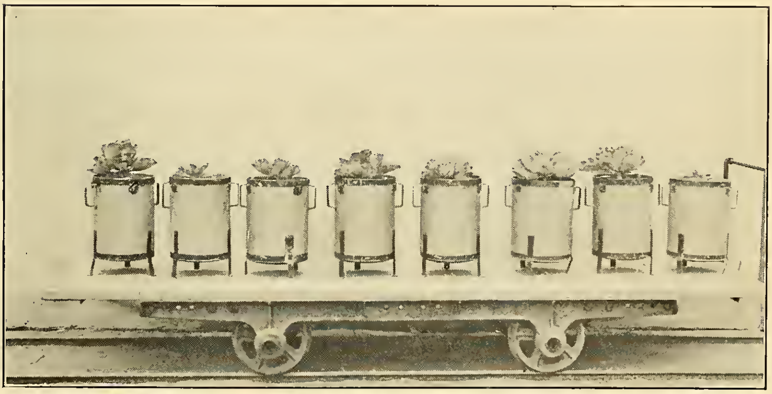
Our experiments indicate the use of phosphates to be especially necessary with all cruciferous crops (cabbage, turnip, cauliflower, Brussels sprouts, rape, etc.).

The onion also, especially if inclined to production of scallions, needs heavy applications of available phosphates.

For crucifers and onions in connection with materials supplying nitrogen and potash, 1,000 pounds per acre of a good acid phosphate, or an



Comparative test of phosphates, Dwarf Essex rape. Cubic capacity of pots, .545 cubic feet; weight of earth, about 17 kilograms at 12 per cent. moisture. All pots received equal and abundant nitrogen and potash. Where supplied, phosphoric acid per pot equals .44 gram. From right to left: no phosphate, dissolved bone black, acid phosphate, dissolved bone, steamed bone meal, South Carolina rock phosphate, Florida rock phosphate, basic slag phosphate (meal).



Comparative test of phosphates, cabbage. Cubic capacity of pots, .545 cubic feet; weight of earth, about 17 kilograms at 12 per cent. moisture. All pots received equal and abundant nitrogen and potash. Where supplied, phosphoric acid per pot equals .56 gram. From right to left: no phosphate, dissolved bone black, acid phosphate, dissolved bone, steamed bone meal, South Carolina rock phosphate, Florida rock phosphate, basic slag phosphate (meal).

equivalent of available phosphoric acid in a good mixed fertilizer, is usually desirable.

The yields of corn and potatoes seem to be in general less dependent upon applied phosphoric acid, but in the more soluble forms a fair amount is desirable, especially where early maturity is an object.

Grasses are affected relatively little by phosphates; clovers are somewhat more responsive, but in top-dressing mowings and pastures the proportion of phosphoric acid should be kept relatively low. Three hundred to 500 pounds per acre of acid phosphate in connection with potash and nitrogen materials, or an equivalent in a complete mixed fertilizer rich in nitrogen, will usually suffice in top-dressing mowings. Slag meal will be especially suitable where a large proportion of clovers is desirable, or in top-dressing soils which are moist and rich in organic matter. It seems also peculiarly adapted for use in connection with potash as a top-dressing for pastures, bringing in the more desirable grasses and white clover. The usual range in quantity needed appears to be between about 500 and 600 pounds per acre.

In orchard management phosphoric acid seems to favor both fruitfulness and good quality, and basic slag meal is in general favor among those who have tried it. This material in orchards, as in mowings and pastures, peculiarly favors clovers and other legumes, and thus indirectly reduces the necessity for nitrogen manuring. It does not, of course, materially affect the need for potash.

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